

Tooth Wear Patterns in Neanderthals and Early Modern Humans

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Anna Clement

Abstract

The overall aim of this project is to investigate adaptive mechanisms involved in the evolution of Neanderthal and Modern Human face morphology. This is done by using a new method to summarise tooth wear patterns in a large collection of Late Pleistocene and Early Holocene hominins. This pattern is interpreted as an indicator of the forces habitually placed on different parts of the dentition. As the characteristic Neanderthal facial morphology is often interpreted as an adaptation to strong bite force between the anterior teeth, it is hypothesised that they should be particularly heavily worn in Neanderthals, relative to the rest of the dentition. The results presented here show that all Late Pleistocene hominins had heavily worn anterior teeth and that this was more pronounced in the Modern Humans than in the Neanderthals. There was, however, a characteristic Neanderthal pattern with wear more evenly spread between anterior teeth, whereas in Modern Humans it was more strongly concentrated in the incisors. In recent hunter-gatherers teeth were an integral part of the toolkit, strongly reflected in tooth wear. Both Neanderthals and the Skhul-Qafzeh Modern Humans shared a Middle Palaeolithic technology, with a small range of tool types and heavy anterior tooth wear, but the much more variable Upper Palaeolithic toolkit did not result in a reduction. Variation between different regions however suggests that the differences are complex. Epipalaeolithic, Mesolithic and Neolithic jaws showed a reduction in the contrast between anterior and cheek tooth wear, as might be expected with the large technological changes they represent.

A preliminary study was made of dental casts from Canadian Inuit whose ages and sexes were recorded. They showed much heavier anterior tooth wear than any archaeological groups. This pattern was established early in life and women had much stronger anterior wear than men. This was related to sexual division of labour and it is striking that in Neanderthals the situation seems to have been replicated.

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Note

Please note that all dates are uncalibrated BP.

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Chapter 1- Introduction

Neanderthals form a well defined group of fossil hominins, sharing a common set of distinctive features that first appear in the fossil record c. 400,000 BP (Stringer and Hublin, 1999) and disappear c. 30,000 BP. Their fossil and archaeological remains have been found at sites throughout Europe and parts of Western Asia. The distinctive combination of their teeth, jaw and facial morphology is unique - not being found in any other hominin, including the early Modern Human fossils from Skhul and Qafzeh, with whom they shared a Middle Palaeolithic technology. The evolution of the Neanderthal face has been the topic of considerable debate and, as will be explored below, much centres on the idea that the Neanderthal anterior dentition (incisors and canines) were habitually used to apply very heavy forces in food preparation, tool making and so on, and that these forces led to the evolution of the unique Neanderthal facial morphology. Neanderthals are well documented for their heavy tooth wear, especially in their anterior teeth, and this has often been used as supporting evidence for their heavy use. What has never been done, however, is to make a comparative study between fossils to find out if Neanderthal tooth wear was in fact exceptional. Skhul, Qafzeh and skulls associated with Upper Palaeolithic technologies also show extremely heavy wear by present day standards – so what should be regarded as “normal” for Late Pleistocene hunter-gatherer tooth wear? Recent Inuit are often cited as an example of such heavy wear and they could undoubtedly generate colossal forces between their teeth, but they lived in a very marginal environment which required a highly specialised toolkit and behaviour, and may not be appropriate for comparison.

The aim of this project is therefore to compare tooth wear between Neanderthals, Middle Palaeolithic Modern Humans, Upper Palaeolithic, Epipalaeolithic/Mesolithic and Neolithic Modern Humans, to assess whether Neanderthals’ anterior teeth were exceptionally heavily worn relative to the rest of their dentition, and compared to other hominin groups. Four research question are proposed:

1. Is the heavy wear found in Neanderthals’ anterior teeth exceptional when compared to that of other Late Pleistocene hominins?
2. Do Neanderthals and recent Inuit hunter-gatherers possess similar tooth wear patterns?

3. Do Neanderthals and Modern Humans who are associated with Middle Palaeolithic tool kits possess a similar tooth wear pattern and does this change during the Upper Palaeolithic and Late Epipalaeolithic?
4. Are Middle Palaeolithic, Upper Palaeolithic and Early Epipalaeolithic Modern Human tooth wear patterns exceptional when compared with the later Modern Humans associated with different tool kits?

We ourselves undergo very little tooth wear during our lives, perhaps partly because of a soft and undemanding diet, but also perhaps because we do not commonly use our teeth for food preparation, or for other tasks where we would normally use some specially designed tool. It is hard for us to realise just how many tasks teeth were used for in the past, or how rapidly they were worn down during life. However, there is considerable ethnographic and fossil evidence to indicate that hominin teeth have been used for a much wider range of physical and cultural activities, some of which have led to considerable wear and abrasion. Some of the most extreme examples seen amongst recent hunter-gatherers have included an Australian aborigine who was observed finely chipping a stone tool with his teeth (Gould, 1968), and an Inuit man from Greenland using his front teeth to prise open the lid of a gasoline steel drum (de Poncins, 1941). However, there are many less exceptional and more routine examples of the teeth being used in various forms of manipulation.

The morphology of the hominin dentition has evolved to withstand heavy tooth wear. Once the top layer of enamel is worn away, the dentine (a hard yellow coloured material often stained brown in archaeological contexts) is exposed. When this dentine is worn through, secondary dentine is uncovered, which protects the pulp cavity. Studies of tooth wear have the potential to provide us with information about the diet of an individual as well as other functions their teeth might have performed, such as craft activities, use as a clamping device, use for shaping objects, cracking nuts or bones, chipping stones tools or chewing materials.

One of the main difficulties in studying tooth wear lies in finding a method to record the extent of wear consistently which can be used, not only in original specimens, but also in photographs, published pictures and casts. As crucial specimens are spread through many museums around the world, this is very important if a large collection of observations is to be assembled. In addition, there is the problem that tooth wear increases with age and the age-at-death of the specimens is not independently known, so it is difficult to compare them with one another. For this project, a newly developed

method was used to measure the pattern of wear through the dentition. Comparisons were carried out using ratios, removing the need for a measurement scale in published photographs and making it possible to compare directly individuals of different ages. Using these methods, it was possible to assemble a large database of wear pattern measurements and this was used to address the research questions.

Chapter outline

Chapter 2 reviews the methods available for recording tooth wear, identifying the shortcomings and restrictions associated with each method. Chapters 3 and 4 examine the archaeological and anthropological background to the questions. They discuss in them the Neanderthals, Palaeolithic-Neolithic Modern Humans and the Inuit of Alaska, Canada and Greenland, including information concerning their environment, tool technologies, hunting strategies and skeletal morphology. From these reviews Chapter 5 defines in detail the four main research questions. Chapter 6 presents a newly developed quantitative method for recording tooth wear. Chapter 7 provides a description of the specimens examined for this study and the archaeological contexts from which they have come. Chapter 8 presents the detailed results of all the analyses undertaken and Chapter 9 discusses the significance of these in relation to the four research questions outlined above. Chapter 10 provides a summary of the main conclusions of this study as well as suggestions concerning future research.

Chapter 2 - Tooth wear

Tooth wear is the result of contact between each tooth and its neighbours, or contact with foreign bodies in the mouth, such as food, materials, artefacts, grit and so on. Some wear must occur during mastication, the cycle of repetitive jaw movements which is used to crush food between the occlusal surfaces of the teeth and arrange it into a bolus ready for swallowing. Mealtimes, however, only occupy a small proportion of every 24 hours and the teeth are brought together forcibly in other ways. Some of this is involuntary and, even if there is no food in the mouth, there may be abrasive particles from a whole variety of sources. Some is deliberate, such as in cutting tape or thread, or holding an object to leave both hands free. Today such actions are relatively uncommon, as we have a large array of specialised tools to carry out these tasks. In the past, teeth were used for a large variety of tasks, such as initial preparation of food, preparation of materials such as leather and fibres, woodworking and even flaking stone tools. This was particularly true of hunter-gatherers, as has been well documented from ethnographic evidence (Wright, 1977). Mastication generally involves relatively low forces, carefully applied. Other tasks, or even involuntary grinding of the teeth (so-called bruxism) appear to involve much greater forces and may continue for much longer periods (Hillson, 1996) so that they may well have had a considerably greater effect on tooth wear than eating itself. In addition, the surfaces of teeth which do not come into contact with other teeth become worn through contact with foreign bodies. The most striking example of this today is toothbrush abrasion, which produces a high gloss surface to the enamel and can undermine the softer dentine where this is exposed through periodontal disease. In the past, this did not occur, but non-contact surfaces nonetheless became worn.

The initial assumption of this project is that teeth in Late Pleistocene and Early Holocene hominins would have formed an integral part of the tool kit, as they did in recent hunter-gatherers. Visits by dentists to such groups recorded remarkably heavy tooth wear, similar to that of the Pleistocene hominins, but unlike the very slight wear seen in modern people from industrialised countries. Ethnographic accounts make it clear that the rapid tooth wear of recent hunter-gatherers was related to the way in which they adapted themselves to their environment through their toolkit and behaviour. It seems reasonable to suggest therefore that the pattern of tooth wear

could be used to address questions of jaw function as a mechanism in the evolution of hominin facial morphology.

2.1 Types of tooth wear

The most common types of tooth wear are attrition, erosion and abrasion:

Attrition: Wear produced by tooth-on-tooth contact, between neighbouring and opposing teeth.

Erosion: The chemical dissolution of enamel and dentine by acids not produced by oral bacteria.

Abrasion: The general loss of surface detail through contact with abrasive particles carried on the cheeks, tongue, food and foreign objects.

Attrition

Attrition is caused by tooth-on-tooth contact. This therefore means, that wear facets can occur on all contact points between neighbouring and opposing teeth. Wear between neighbouring teeth, known as approximal, interproximal or interstitial wear, is caused by the small movements of teeth against each other during activities such as chewing and clenching of the jaws. Bruxism, the habitual grinding of the teeth, can be a major cause of both approximal and occlusal wear (Hillson, 1996).

One of the earliest studies of attritional wear (Lysell, 1958) showed that the mesio-distal diameters of teeth decreased with increasing age. In a more recent study, Owen *et al.* (1991) analysed the dentition of a prehistoric population from Oakhurst on the South African coast, finding large approximal wear facets associated with extensive occlusal wear. This was attributed to the substantial forces and prolonged chewing necessary to process their coarse diet.

Erosion

Erosion can be a significant cause of wear in ancient as well as modern populations (Bell *et al.*, 1998; Kieser *et al.*, 2001; Smith and Knight, 1984a) and involves the chemical dissolution of the dentine and/or enamel. The acids that cause erosion can be either extrinsic in nature, such as dietary e.g. carbonated soft drinks and citric fruit juice) or industrial airborne chemicals, or intrinsic, such as hydrochloric acid via gastric

regurgitation (Bell *et al.*, 1998). Erosion is the least studied of the three main types of tooth wear.

A study by Bell *et al.* (1998) demonstrated that scooped dentine on the worn occlusal surface of teeth, displays significant changes in shape when caused mainly by erosion as opposed to attrition or abrasion; dentinal scooping tends to be shallower when caused by abrasion and deeper when caused by erosion. Kieser *et al.* (2001) went on to establish a depth:breadth ratio for scooped dentine, which helps to determine the main aetiology of the wear feature. A ratio of less than 0.25 was considered to be indicative of mechanical wear (attrition or abrasion), while a ratio of more than 0.25 was taken to represent erosion (Kieser *et al.*, 2001). They found that erosion, interacting with abrasion, was responsible for a sharp increase in the occlusal wear seen in the teeth of Maori settlers after AD 1500. This interaction was confirmed by micro-wear analysis of the examined collection.

In a survey of 100 patients referred with problems of excessive tooth wear, dietary and regurgitation erosion were found to be the most common causes with regurgitation erosion resulting in the most severe damage (Smith and Knight, 1984a).

Abrasion

Tooth abrasion is the most common cause of tooth wear and is consequently the most widely studied. It involves the general loss of the surface detail of a tooth through contact with abrasive particles, which can continue until the crown has been completely worn away. These abrasive particles are comprised of many different forms including dietary grit, stone and organic implements, animal hide and meat, smoking equipment and oral jewellery.

One of the most extreme cases of tooth abrasion is the deliberate cutting and grinding of teeth, which has been identified in several South American populations (Romero 1958; 1970). The studies by Romero (1958; 1970) document dramatic changes in a tooth's surfaces through cuts, file marks and drill holes, and the insertion of inlays.

Attrition, erosion and abrasion each produce distinct patterns of wear - however, a tooth is rarely subject to a single form of wear. Rather, teeth must cope with the accumulative damage that results from a suite of diverse factors, such as wear from other teeth, food consistency, grit in the diet and acidic erosion.

2.2 Factors affecting tooth wear

Patterns of tooth wear are influenced by a combination of biological, physical and cultural determinants (Barrett and Brown, 1975):

Biological: Tooth size and shape, hardness of dental tissue, position of individual teeth within the dental arches, size and shape of the dental arches, relation of upper and lower dental arches and the state of health of teeth and the supporting tissue.

Physical: Chemical properties, texture and abrasiveness of food and other incorporated foreign material.

Cultural: Manner of gathering food and preparing it for eating, the use of the dentition as tools and the intentional modification for personal ornamentation e.g. lip plugs, filings, chippings and inlays.

All of the above factors have the potential to create unique wear patterns, causing great differences between and within populations.

Biological determinants

The biological determinants listed above all form part of the masticatory system, which includes the teeth, temporomandibular joints, and the supporting craniofacial skeleton. All components of this system have the potential to influence patterns of tooth wear (Richards, 1990). Molnar and Molnar (1990), for example, studied the relationship between arch shape and the distribution of wear facets and exposed dentine over occlusal surfaces. Examination of 64 stone dental casts of Australian Aborigines from Yuendumu, Central Australia showed that individuals with hypsoid, or U-shaped, maxillae had a more buccally orientated wear, while those with parabolic or hyperbolic form maxillae exhibited much heavier lingual loading.

Physical determinants

Out of the many physical determinants listed above, the hardness of particles contained within the diet of a specific group of individuals is one of the strongest influences on tooth wear, especially occlusal wear. Hinton (1981), for example, related the different tooth wear patterns of groups of Australian Aborigines, Inuit of Greenland and Canada, Native Americans and Ohio Woodlanders to the varying abrasiveness of

their diets. Smith (1984) noted that hard particles introduced into the diet through the grinding of cereals with stone tools during the Neolithic period caused an increase in the amount of wear and a change in the angle at which a tooth was worn. It could be argued that these types of physical determinants are also cultural determinants; the grinding of food, for example, not only affects the hardness of the particles in the diet but also represents a cultural activity.

Cultural determinants

Cultural practices vary between and within societies both past and present, and these differences can have a lasting effect on an individual's dentition. One of the most well known examples of a cultural behaviour impacting significantly on tooth wear comes from the Inuit. Pedersen (1947) clearly documented groups of Inuit using their front teeth to soften seal-hide to enable its use for clothing and shoes, which had a visible impact on the reduction of their anterior teeth. Another example is the presence of circular notches on the incisal and occlusal edges of teeth, as identified by Hillson (1996), in a collection of post-medieval skulls from London. This pattern of wear was interpreted as the result of gripping clay pipe stems between the teeth while smoking.

2.3 Identifying cause

There have been numerous attempts to identify the major causes of tooth wear within specific populations and individuals. One of the main problems in assessing the aetiology of tooth wear is that it is usually caused by a multitude of different factors. Johansson *et al.* (1991), for example, noticed that tooth wear in a young Saudi population was substantially higher than those of modern Western populations. When trying to determine the aetiology of this heavier wear no single main cause, such as habitat, could be identified. Instead, multiple factors such as bruxism, the use of a special wooden chewing stick/tooth brush (*miswak*), nail- or pen-biting and fruit juice consumption were found to be the major causes (Johansson *et al.*, 1991). Most surprising was that no connection to habitat was detected.

Due to the many problems associated with identifying the major causes of tooth wear in historic and prehistoric populations, other sources of evidence are used, including historic literature, associated archaeology and ethnographic reports. Larsen (1985) combined archaeological data with the ethnographic literature to identify the causes of transverse grooves located on the mid-occlusal surfaces of the anterior teeth in pre-

contact hunter-gatherers from the western Great Basin. These grooves were attributed to the modification of plant materials to produce utilitarian objects such as fishnets and basketry. Molnar (1971), reported differences in male and female tooth wear among the skeletal remains of Native Americans. Molnar (1971) attributed these differences to the use of teeth in cultural activities and the division of labour, e.g. basket making activities in females, based on the ethnographic literature.

Lukas & Pastor (1988) studied tooth wear in Neolithic and Chalcolithic populations from Mehrgarh and Harappa, Pakistan. Evidence from ethnographic reports of modern hunter-gatherers was used to aid the interpretation of macroscopic and microscopic patterns of tooth wear exhibited by these Neolithic and Chalcolithic peoples. It was concluded that the interproximal grooves found on many of the teeth resulted from pulling the fibrous materials between the teeth or the use of toothpicks, behaviours that have been observed in both Australian Aboriginal people and Native American populations.

2.4 Techniques for measuring tooth wear

The study of tooth wear patterns in both modern and ancient human populations has a long research history, the very earliest study being conducted by Broca at the end of the 19th century (Broca 1879). These early studies were motivated by the fact that, once recorded, tooth wear patterns can be used to make inferences about diet, food preparation techniques, and habitual activities involving the teeth. Tooth wear also forms one of the most useful skeletal markers with which to age adult skeletons. Consequently, a wealth of literature has been published describing and testing various methods for recording tooth wear (Brothwell, 1981; Kambe *et al.*, 1991; Miles, 1962; Molnar *et al.*, 1983a; Richards, 1984; Richards and Brown, 1981b; Scott, 1979b; Smith, 1984; Walker *et al.*, 1991). This literature includes both micro- and macro-wear, ordinal and quantitative techniques, and occlusal and non-occlusal studies.

Micro-wear

Studies of tooth enamel micro-wear using scanning electron microscopy (SEM) currently dominate the field of tooth wear studies (Boyde, 1974; Boyde, 1979; Bullington, 1991; Gordon K.G., 1988; Grine, 1987; Grine and Kay, 1988; Kay, 1987; Lalueza, 1992; Lalueza *et al.*, 1996; Nowell, 1978; Pastor, 1992; Puech, 1992; Rose and Harmon,

1986;Rose and Tucker, 1994;Scott, 1979b;Smith, 1984;Teaford, 1988;Teaford and Lytle, 1996;Teaford and Walker, 1984;Ungar *et al.*, 1990;Ungar, 1995;Walker *et al.*, 1991;Walker, 1979;Walker and Hagen, 1994). SEM analysis provides data on the size and quantity of dietary particles through abrasive inclusions located on the surfaces of human or animal teeth. A visual assessment and quantification is made of these abrasive features, such as facets, pits and scratches, which appear on a tooth's surface. This work is generally undertaken on photographic prints of SEM images, where these features are traced and quantified or plotted into a computer software program.

Micro-wear features have a short temporal life, which provides an opportunity for assessing dietary change and even seasonality of death (Buikstra *et al.*, 1994). In fact, even daily or weekly changes in enamel surfaces have been detected on human teeth (Teaford and Tylenda, 1991).

While micro-wear analysis represents an exciting and relatively new development in tooth wear research, it does have several disadvantages. The short temporal life of micro-wear features can cause difficulties when trying to accurately reconstruct the diet of an individual if their food supply was highly seasonal. The features produced by hard foods also tend to predominate over less marked features produced by soft foods (Hillson, 1996). The technique is extremely time consuming and is based on the enamel surfaces of teeth, so individuals with extreme wear, where very little enamel remains, cannot be accurately examined using this method.

Macro-wear

Whilst use of SEM to investigate micro-wear currently dominates the field of tooth wear studies, it is a relatively recent development, whereas macro-wear studies have been practiced for more than one hundred years. This long history has meant that a large number of macro-wear techniques and methods have been developed. The techniques outlined below involve varying levels of complexity and technology, and all have their advantages and disadvantages. These techniques can be divided into two main groups: ordinal and quantitative. Ordinal techniques are based on evaluating the amount of wear and placing it into a discrete category, whereas quantitative techniques measure wear on a continuous scale.

Ordinal techniques

Ordinal techniques involve the visual assessment of the amount of wear present on each tooth/set of teeth within the human dentition. They have been widely applied to both living and skeletal collections of humans (Aykroyd *et al.*, 1999; Davies and Pedersen, 1955; Drier, 1994; Johansson *et al.*, 1991; Johansson *et al.*, 1993; Kieser *et al.*, 1983; Lavelle, 1969; Lunt, 1978; Owen *et al.*, 1991; Smith and Knight, 1984b; Smith, 1972). The complexity of these types of methods varies greatly from simple descriptions with few wear categories to the scoring of each tooth on a 100-point scale.

Simple descriptions

The first ordinal method for recording tooth wear was developed by Broca (1879), who proposed a simple and progressive six-stage system, whereby 0 represented no wear, and 5 represented a tooth with the crown completely worn away, down to the cementum. All subsequent ordinal methods are variations and developments of this simple method. Davies and Pedersen (1955), for example, used a 4-stage system for recording wear: 0 = no attrition; 1 = attrition of the enamel; 2 = exposure of dentine, and 3 = exposure of secondary dentine or pulp. Despite its simplicity, this method was effectively used to record substantial differences in tooth wear between two Inuit groups from Greenland. These differences were attributed to varying diets between native and urbanised groups (Davies and Pedersen, 1955).

Smith (1972) used a slightly more complex version of this descriptive method; a simple 5-point scale that scored each of the main cusps separately. This gave a maximum score of 20 for each tooth but was restricted to use on the molars. Applying this method to different Natufian populations showed distinct differences between these Natufian populations that were attributed to the varying abrasiveness of their diets (Smith, 1972).

Simple descriptions of tooth wear are also commonly used in clinical dentistry (Johansson *et al.*, 1991; Smith and Knight, 1984b). Smith & Knight (1984) developed a tooth wear index (TWI) whereby written descriptions, based upon a scale of 1 to 4, were used to record wear on four surfaces of each tooth. This index resulted in a maximum of 128 tooth surfaces being recorded per patient. Johansson *et al.* (1991) used a similar four-stage scale to demonstrate higher levels of tooth wear in a young Saudi population when compared with modern Western samples, most notably highlighting heavy anterior wear in the former of the two groups studied.

Pictorial methods

Broca's (1879) descriptive recording system was developed and expanded into an eight-stage pictorial system by Murphy (1959). This consists of a series of 'modal forms' graded from *a* to *h*, supported by a series of diagrams that illustrate the varying levels of dentine exposure on the occlusal surface of the molars (Fig. 2.4.1). The number of individuals within a collection that matches the various stages of wear is recorded in the bottom right hand corner of each occlusal diagram (Fig. 2.4.1).

This method was applied to a group of Australian Aborigines in whom a distinct pattern of molar wear was established (Murphy 1959). While proving a success this method involved a large number of pictures and descriptions, as each molar is recorded separately. This led to the development of a series of more simple pictorial methods. Molnar (1971), for example, developed a method that uses Murphy's eight stages of wear but groups individual teeth into three categories: incisors and canines; premolars, and molars. This method also includes the appearance of secondary dentine in the written and pictorial descriptions of several of the wear stages.

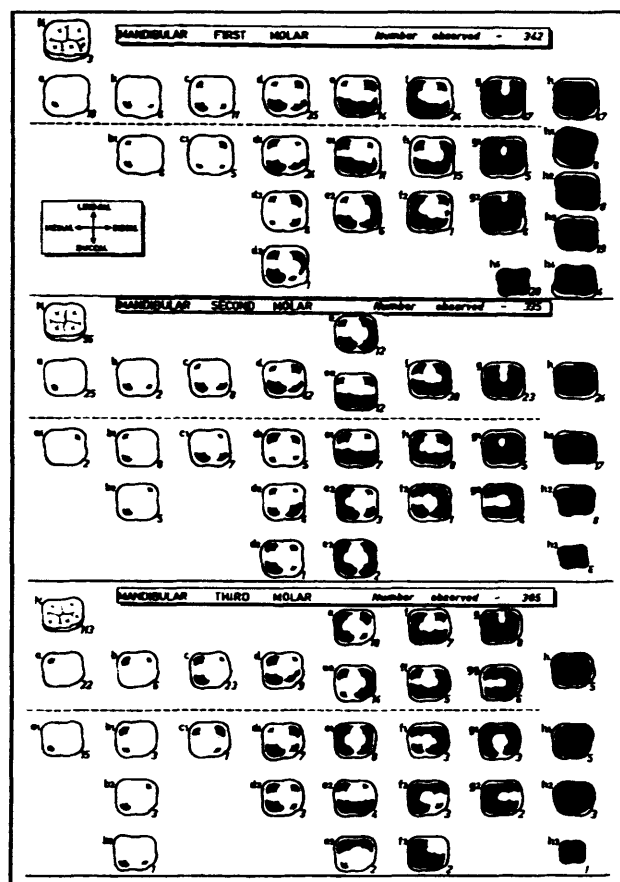


Figure 2.4.1: Murphy's method for recording tooth wear in the mandibular molars, taken from Murphy (1959).

One of the most commonly used diagrams for recording tooth wear is Smith's (1984), who also produced a summary of Murphy's diagrams (Murphy 1959). The main benefit of this diagram is that the clear and simple drawings makes tooth wear easier to record and faster to apply to large collections (Fig. 2.4.2). As with Molnar's method (Molnar 1971) the dentition is divided into molars, premolars, and incisors and canines. Eight stages of wear are illustrated for each tooth category, with each wear stage containing two-to-three pictures, illustrating the range in wear (Fig. 2.4.2). The pictorial diagrams used in this method are also accompanied by written descriptions of the stages seen.

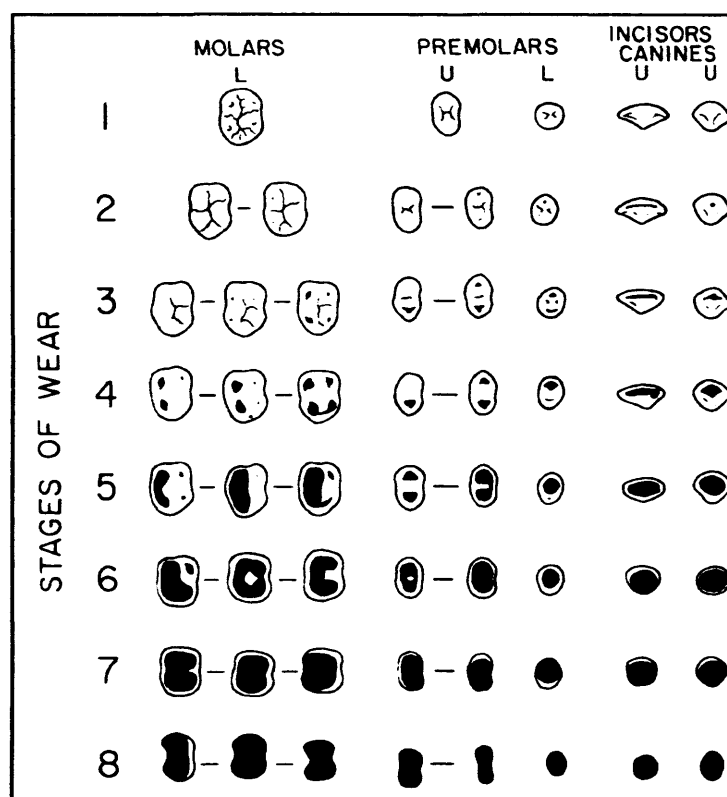


Figure 2.4.2: Smith's adaptation of Murphy's method for recording occlusal tooth wear, taken from Smith (1984).

Owing to the practical limitation in the number of wear categories used, the ordinal methods outlined above discriminate poorly when attrition rates are moderate. In contrast, Scott (1979a) developed a method that records smaller differences in levels of wear. This method divides the molars into four sections, each of which is then scored separately on a scale of 1 to 10 (Fig. 2.4.3), giving a possible range of scores for one tooth of between 4 and 40. This scale is related to the amount of enamel and

dentine present in each quarter of a tooth. Either written or pictorial descriptions, or both, are provided for each score category (Fig. 2.4.3).

This method produces fewer duplicate scores than the more simple ordinal methods, such as Molnar's (1971) and Smith's (1984), thereby reducing measurement error. Indeed, low inter- and intra-observer error were observed (Scott, 1979a) - however, it was also noticed that one of the scorers in the study marked consistently lower than the other.

Attrition scoring technique		
Score	Description	
0	No information available (tooth not occluding, unerupted, antemortem or postmortem loss, etc.)	
1	Wear facets invisible or very small	
2	Wear facets large, but large cusps still present and surface features (crenulations, noncarious pits) very evident. It is possible to have pinprick size dentine exposures or "dots" which should be ignored. This is a quadrant with <i>much</i> enamel.	
3	Any cusp in the quadrant area is rounded rather than being clearly defined as in 2. The cusp is becoming obliterated but is not yet worn flat.	
4	Quadrant area is worn flat (horizontal) but there is no dentine exposure other than a possible pinprick sized "dot."	
5	Quadrant is flat, with dentine exposure one-fourth of quadrant or less. (Be careful not to confuse noncarious pits with dentine exposure.)	
6	Dentine exposure greater: more than one-fourth of quadrant area is involved, but there is still much enamel present. If the quadrant is visualized as having three "sides" (as in the diagram) the dentine patch is still surrounded on all three "sides" by a ring of enamel.	
7	Enamel is found on only two "sides" of the quadrant.	
8	Enamel on only one "side" (usually outer rim) but the enamel is thick to medium on this edge.	
9	Enamel on only one "side" as in 8, but the enamel is very thin - just a strip. Part of the "edge" may be worn through at one or more places.	
10	No enamel on any part of quadrant - dentine exposure complete. Wear is extended below the cervicoenamel junction into the root.	

Figure 2.4.3: Scott's method for recording occlusal tooth wear, taken from Scott (1979a).

The main disadvantage of Scott's (1979a) method is that it can only be used on the molars. The premolars, canines and incisors must be recorded using other, less complex methods, making comparisons between the teeth difficult. It is also a more time-consuming technique than other ordinal methods.

Drier (1994) developed an even more detailed ordinal method, in which the molars are again divided into four quadrants, each of which is scored separately. In this method wear is recorded on an even larger scale consisting of 26 stages. The most interesting point to note about this scale is that it was produced by mechanically grinding 20 molar

teeth and recording the amount of wear that occurred at 25 equally spaced intervals. This detailed scale highlighted intra-population variation in tooth wear within a skeletal group of Arikara Indians from South Dakota, USA (Drier, 1994). Female tooth wear in this population was found to be distinctively different to that of the males in its relationship to age and its variance of scores.

The ordinal techniques outlined above have several advantages: they are easy to learn, speedily applied, and require no specialised equipment. They can, therefore, be applied to large skeletal collections. The boundaries between each wear class are, however, subjective, i.e. two individuals could assign the same tooth to different wear categories. These ordinal methods also have statistical disadvantages as they produce discrete and non-continuous data. As noted by Behrend (1977), while these ordinal scales are useful for gross comparisons, a system based on a continuous scale more accurately reflects the continuous nature of the wear process and permits statistical testing.

Quantitative Methods

Many of the disadvantages associated with ordinal methods can be eliminated through the use of quantitative methods. Several types of quantitative recording methods have been developed over the past few decades and include: the measurement of the area of wear facets from photographs of the tooth's occlusal surface using a planimeter (Behrend, 1977; Molnar *et al.*, 1983a; Richards, 1984; Richards and Brown, 1981b; Richards and Miller, 1991; Walker, 1978) or a computer-based image system (Kambe *et al.*, 1991), and the calculation of enamel lost through wear using height measurements (Benfer and Edwards, 1991; Kieser *et al.*, 1985; Mays *et al.*, 1995; Mays, 2002; Mehta and Evans, 1966; Molnar *et al.*, 1983b; Murphy, 1964; Tomenchuck and Mayhall, 1979; Walker *et al.*, 1991).

Crown/cusp height

It is widely known that the dimensions of a tooth crown decrease with wear. This is especially pronounced for the crown height dimension. Consequently, numerous techniques have been used to record the height of tooth crowns and their cusps in skeletal and living collections (Benfer and Edwards, 1991; Kieser *et al.*, 1985; Mays *et al.*, 1995; Mays, 2002; Mehta and Evans, 1966; Molnar *et al.*, 1983b; Murphy, 1964; Tomenchuck and Mayhall, 1979; Walker *et al.*, 1991). Crown height is difficult to measure accurately and has led to the development of a large number of different methods and techniques. Some workers used a single measurement per tooth,

measuring from the cemento-enamel junction to either the highest part of the crown (Benfer and Edwards, 1991) or the tip of one particular cusp (Kieser *et al.*, 1985). Walker *et al.* (1991), for example, recorded the height of the crown as the distance from the cervical margin to the worn occlusal surface. However, given the uneven nature of tooth wear, taking a single measurement may prove inadequate in many cases.

Van Reenan (1982) described some of the dimensional changes that took place as a result of wear in the teeth of a group of San Bushmen skulls. This study supported the idea that all the dimensions of a tooth are influenced by wear; crown height the most and the labio-lingual length the least (Van Reenen, 1982). A tendency for crown height to be reduced more in the incisors and canines than in the molars was also demonstrated in this study, but this most likely reflect a characteristic specific to this particular hunter-gatherer group.

Mays *et al.* (1995) recorded two crown height measurements, one each in the mesial and distal quadrants of the buccal side of the mandibular molars and in the lingual side of the maxillary molars. These measurements focus on the parts of the crown in which wear is likely to be the greatest. This method was applied to a 19th century collection from the Netherlands (Mays, 2002) and a close relationship between crown height and age-at-death was found. Other studies (Mehta and Evans, 1966; Walker *et al.*, 1991) have taken measurements of all four quadrants of the tooth crown.

Contrasting crown measurements have been based on cusp height relative to the central fossa (Molnar *et al.*, 1983a; Tomenchuck and Mayhall, 1979). Tomenchuk & Mayhall (1979) used callipers and a depth gauge to record cusp height, maximum mesio-distal length and maximum bucco-lingual width in a group of dental casts taken from the Igloodik Inuit from the Northwestern Territories, Canada. A linear regression model was derived from these measurements and used to test the degree of correlation between known age and tooth wear. This model was successfully used to predict the ages of Inuit from the neighbouring population of Hall Beach.

One of the main problems with these crown height techniques is that the height of unworn crowns is highly variable within and between any populations (Hillson 2000). This means that comparisons between populations and individuals are limited in accuracy if their original crown height is unknown. The definition of a crown height

measurement also requires attention as the variety of methods and techniques used can make meaningful comparisons difficult.

3-D modelling of tooth wear

The initial stages of tooth wear (pre dentine exposure) are difficult to quantify and have, therefore, received limited attention (Lambrechts *et al.*, 1989; Mehta and Evans, 1966; Teaford and Tylenda, 1991; Tomenchuck and Mayhall, 1979). In populations with very low wear rates, and in young individuals, dentine is often not exposed but there may be evidence of wear on the enamel. This wear cannot be recorded in detail using ordinal scales or, indeed, many quantitative methods. Methods to record cusp height have been developed (Mehta and Evans, 1966; Molnar *et al.*, 1983b; Tomenchuck and Mayhall, 1979) but unfortunately these can be limited in their accuracy, due to variation in cusp size and shape.

Mayhall and Kanazawa (1989) developed a method using moiré contourography to determine cusp height and enamel wear. Casts were photographed using moiré contourography, and the heights of individual cusps were obtained by counting the number of contour lines from the mesio-buccal fossa to the top of the cusp. Mayhall & Kageyama (1997) combined moiré contourography with digital image analysis to determine not only the reduction in cusp height, but also the actual amount of tooth material lost through attrition and abrasion. Whilst being an extremely accurate and effective method for recording enamel wear, it is very time consuming, requires specialist equipment and currently can only be applied to molars.

Measuring tooth wear from photographs

Photographs have also been used as a tool for quantifying and measuring tooth wear (Behrend, 1977; Kambe *et al.*, 1991; Molnar *et al.*, 1983b; Richards and Brown, 1981a; Richards, 1984; Richards, 1990; Walker, 1978). One of the first studies of this kind was undertaken by Behrend (1977), who measured tooth wear in a sample of 100 individuals from a Middle Woodland mortuary population, west-central Illinois. Photographs of the occlusal surfaces of teeth were enlarged to highlight the areas of exposed dentine and enamel. Percentage areas of both the dentine and enamel were then calculated from the enlarged photographs. Tooth wear was expressed as the percentage of total occlusal surface area that was exposed dentine. The results of this study showed that wear scores based on area quantification are more sensitive estimates of tooth wear than other ordinal scales.

Walker (1978) applied this type of method to coastal and inland groups of Native Americans from the Santa Barbara Channel area. The area of occlusal dentine was, as in Behrends (1977) study, measured from photographs taken with the camera's focal plane perpendicular to the occlusal surface of the tooth. A millimetre scale orientated parallel to, and at the level of, the occlusal surface was included in each photograph. Photo negatives were then projected and enlarged onto paper and the outline of the molar crown and dentine measured using a planimeter. This method highlighted differences in tooth wear rates between the inland and coastal populations that were previously invisible using ordinal methods.

These photographic methods are time consuming when compared with ordinal methods. However, a major advance was made by Kambe *et al.* (1991) using a computer-based image system instead of a planimeter to measure wear, greatly reducing the amount of time needed to record the wear on each tooth.

Quantitative methods represent a more accurate way of measuring tooth wear and allow a broader statistical use of the data (Kambe *et al.*, 1991; Walker, 1978). More subtle intra- and inter-population differences, which often remain undetected by ordinal methods, can also be identified when tooth wear is recorded tooth-by-tooth. Many of the quantitative methods are, however, time consuming and require specific equipment and computer software.

Angle of wear

All of the previously described methods have concentrated on recording amounts of occlusal wear. However, interesting and useful results can also be achieved by measuring the angle of this occlusal wear. Murphy (1964), for example, as well as developing an ordinal method for recording tooth wear, also used the depth gauge on vernier callipers to measure the height difference between the most severely worn side of the molars and the plane formed by the most elevated portions of a molar pair. This enables the calculation of the angle of wear in the teeth examined.

Smith (1984) developed an accurate method for recording the angle of wear in teeth using a modified protractor (Fig. 2.4.4). Smith found that hunter-gatherers maintained relatively flat wear, whereas agriculturalists showed a more restricted pattern of wear and tended to develop oblique wear planes. This distinction is attributed to the reduction in toughness of food seen in a grain-based diet, compared with a hunter-

gatherer diet, and due to the increased fibrousness of food and associated intensive use of grinding stones and pottery in food preparation (Smith, 1984).

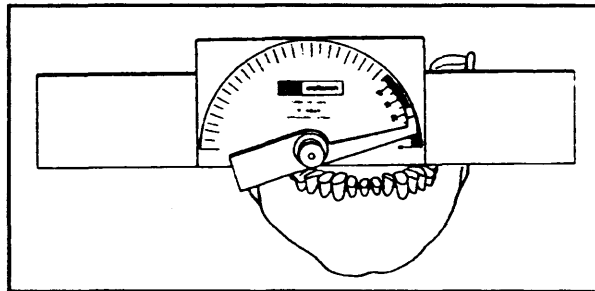


Figure 2.4.4: A modified protractor used to measure the gradient of tooth wear on the occlusal surface of a tooth, taken from Smith (1984).

Non-occlusal tooth wear

Tooth wear can occur on all five surfaces of a tooth but is rarely recorded using a common method on any surface other than the occlusal. This is mainly because non-occlusal tooth wear is highly variable and therefore difficult to standardise or categorise. Though non-occlusal tooth wear has been reported in detail, for features such as chipping and inter-proximal grooves (Berryman *et al.*, 1979; Brown and Molnar, 1990; Formicola, 1988a; Schulz, 1977; Turner and Cadien, 1969; Uberlaker *et al.*, 1969), these reports are mostly descriptive.

While many interesting, descriptive accounts of non-occlusal wear continue to be published there is, at present, no standardised method for recording the various types of non-occlusal wear. Until standard methods are developed comparisons of non-occlusal wear between and within populations remain problematic.

2.5 Development of tooth wear with age

The amount of tooth wear experienced by an individual is strongly correlated with their age, i.e. the older an individual the more tooth wear they will possess. Measurements of tooth wear have, therefore, frequently been used to estimate the ages of individuals from archaeological and forensic collections (Aykroyd *et al.*, 1999; Brothwell, 1981; Lovejoy, 1985; Mays *et al.*, 1995; Mays, 2002; Miles, 1962; Molleson and Cohen, 1990; Molnar *et al.*, 1983a; Nowell, 1978). The most commonly used method is that of

Brothwell (1981), which uses an ordinal recording technique. The amount of wear on each of the molars is separated into four categories and each category is allocated an age range. Each of these categories is defined through pictorial drawings of the occlusal surfaces of molars with varying amounts of dentine exposed (Fig. 2.4.5). This method was intended for use on prehistoric-to-early medieval British material but has since been applied throughout the world.

Age Period (years)	About 17-25			25-35			35-45			About 45		
Molar number	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
Wear pattern			Dentine not exposed. There may be slight enamel polishing.							Any greater degree of wear than in the previous columns.		
	OR											
	OR									NB. Very unequal wear sometimes occurs in the later stages.		

Figure 2.4.5: Brothwell's method for aging an individual based on their tooth wear, taken from Brothwell (1981).

One of the main problems with applying this technique to different populations is that the rate of tooth wear can vary greatly within and between different populations. If applied to a group whose teeth are worn at a slow rate, for example, the ages of individuals within that group would be greatly underestimated. Similarly if a group's teeth are worn at a very high rate, many individuals will be assigned an age much older than their actual age.

The Miles (1962) aging method takes into account this inter-population variation in wear rate by calculating a wear rate that is population-specific. This is achieved by measuring tooth wear in children from the selected group between the ages of 6 and 19 years old (whose age can be calculated independent of wear using the dental development sequence). The tooth wear in the immature individuals is then used to calculate a wear rate and to create a baseline. It is then possible to predict the age of adults from the same population based upon their tooth wear (Fig. 2.4.6). One of the major limitations of this method is that it can only be applied to a dental collection that contains at least 20 immature individuals aged between 6 and 19 years. Another problem with this method is that the further away from the baseline the data moves the less reliable the method becomes (Kieser *et al.*, 1983). The method also assumes a

constant rate of wear throughout an individual's life, whereas wear can often vary over time according to social status, sex and personal preference for things such as food.

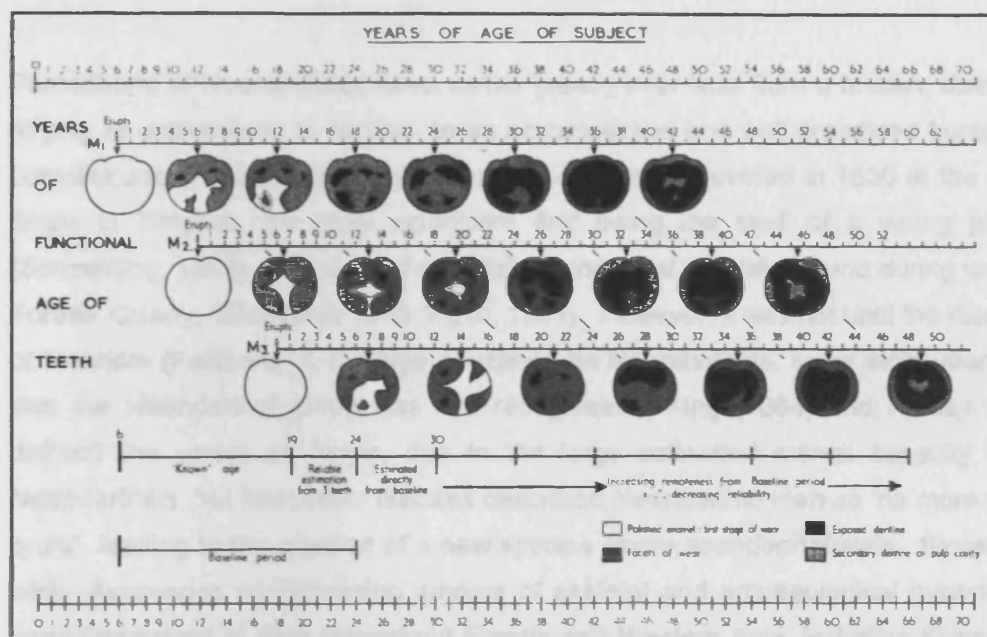


Figure 2.4.6: Miles' system for age assessment from tooth wear, taken from Miles (1962).

2.6 Summary

The process of tooth wear is complex, being affected by a multitude of different factors. It is generally caused by tooth-on-tooth contact, contact with erosive chemicals or abrasive particles and objects being placed in the mouth, although these are often hard to separate. Tooth wear patterns are also influenced by numerous factors, such as: the shape of the dental arcade and the position of teeth within them; the abrasiveness of the food being consumed; the cultural use of teeth as tools, as well as intentional mutilation. A combination of these factors and causes leads to the production of unique wear patterns both within and between populations.

Since the end of the 19th century, a wide variety of techniques have been developed to record tooth wear. They include micro and macro methods, ordinal and quantitative, 2-D and 3-D, as well as occlusal and non-occlusal, and all have their advantages and disadvantages. The selection of a method by a researcher is dependent on the questions being asked and the type of material being studied. The type of method employed in the current study was selected using the criteria outlined in Chapter 6.

Chapter 3 – The Neanderthals

Perceptions of Neanderthals have varied greatly over time from a brutish, dull figure relying on scavenging to survive, to an accomplished and well-organised hunter with complex social behaviour. Their remains were first discovered in 1830 at the site of Engis in Belgium, the most significant find being the skull of a young juvenile (Schmerling, 1833). The skull of an adult Neanderthal was later found during works at Forbes' Quarry, Gibraltar in 1848 (Keith, 1911). However, it was not until the discovery of Neander (Feldhofer) I, the type specimen for Neanderthals, some eight years later that the Neanderthal group was first recognised. King (1864) and Huxley (1864) defined the genus as *Homo*, due to the large estimated cranial capacity of the Neanderthals, but from other features described Neanderthal man as 'no more than a brute', leading to the creation of a new species *Homo neanderthalensis*. Since these early discoveries an increasing amount of skeletal and archaeological material has been uncovered at sites throughout Europe and Western Asia, including Krapina, La Quina, Spy and Tabun, and more recently Zafarraya and Vindija.

It is now widely believed that Neanderthals first evolved in Europe from populations of hominins known as *Homo heidelbergensis*, whose fossil remains have been found at sites throughout Europe, including: Mauer, Arago, Boxgrove, Petralona, Sima de los Huesos in Atapuerca, Montmaurin, Swanscombe, and Steinheim. Studies of these materials suggest that a morphological transition was taking place around 400,000 years ago, at a time when these populations found themselves in relative isolation due to geographical and climatic constraints associated with the development of glacial conditions (Hublin, 1998; Lebel *et al.*, 2001). It was suggested that this isolation led to the development of the distinctive Neanderthal morphology.

3.1 The Environment

Chronology and Location

Fossils exhibiting classic Neanderthal features first appear in the fossil record from 400,000 BP at sites such as Swanscombe in England and Atapuerca in Spain (Arsuaga *et al.*, 1997; Stringer and Hublin, 1999). Current evidence suggests that Neanderthals survived until approximately 50,000 BP in Western Asia, and 30,000 BP

in parts of Europe (Barton *et al.*, 1999;d'Errico *et al.*, 1998;Finlayson and Pacheco, 2000;Hublin *et al.*, 1996;Ovchinnikov *et al.*, 2000;Patou-Mathis, 2000;Smith *et al.*, 1999). The continuous discovery of new fossils and the re-dating of many key sites, however, mean that these dates are constantly being revised.

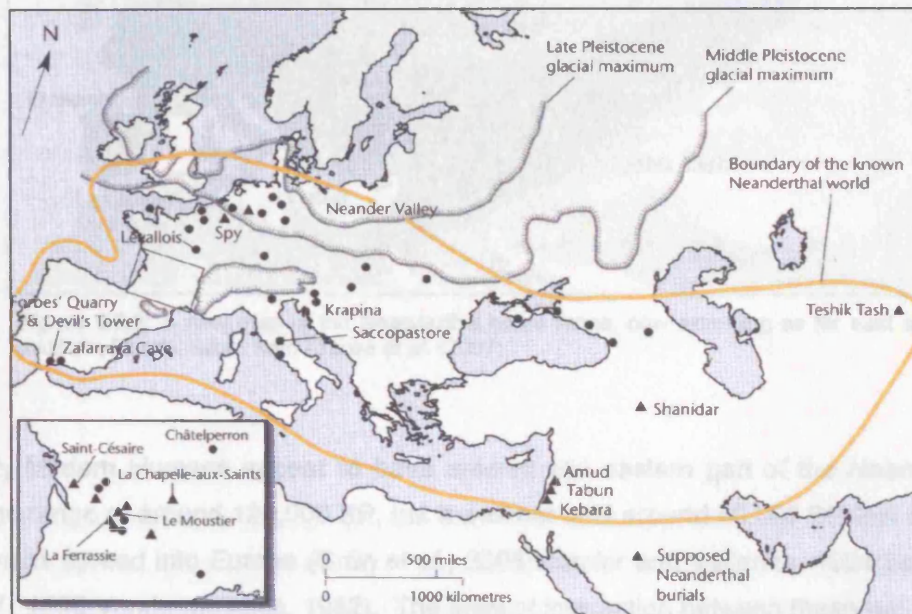


Figure 3.0.1: A map of the major Neanderthal sites and home range, taken from Stringer and Gamble (1993).

While evidence for Neanderthals has been found throughout Europe and parts of Asia, the numbers of sites vary between countries and regions. Until recently the most easterly known Neanderthal site was Teshik-Tash in Uzbekistan (see Fig. 3.0.1), but the recent extraction of Neanderthal DNA from hominin remains at the site of Okladnikov Cave has extended this range as far as southern Siberia (Krause *et al.*, 2007) (Fig. 3.0.2). The best-known Neanderthal sites are either rock-shelters or caves, but also include open-air sites in some instances. These latter sites served a number of different functions, such as base camps, hunting stations, killing and butchering sites, and pigment extraction mines (Patou-Mathis, 2000). They are found in a combination of low level plains, mid-level plateaus and slopes, and high-level mountainous regions (Patou-Mathis, 2000) and many show evidence of repeated occupation throughout the Middle Palaeolithic period.

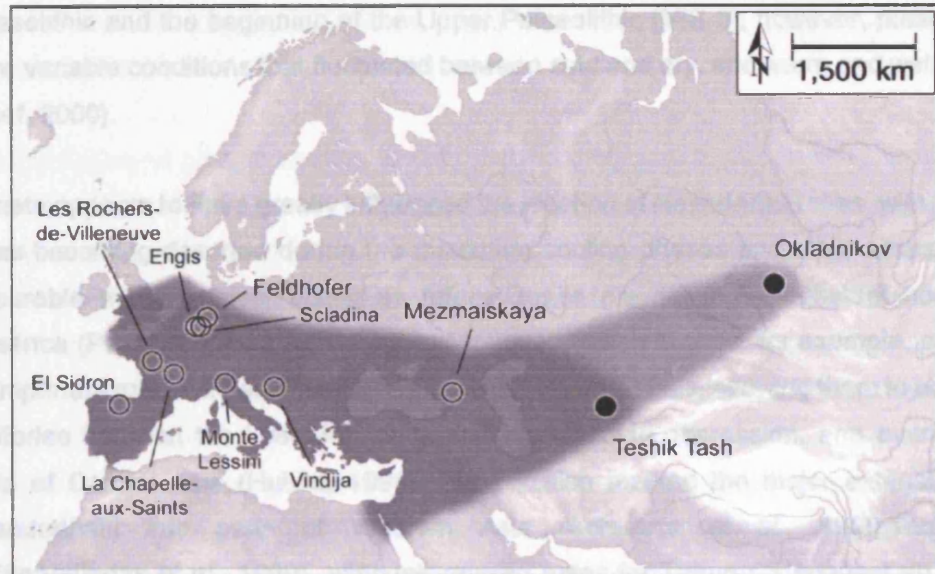


Figure 3.0.2: A new map of the Neanderthal home range, now extending as far east as southern Siberia, taken from Krause *et al.* (2007).

Early Modern Humans appear to have entered the eastern part of the Neanderthal home range at around 120,000 BP, but it was not until around 40,000 BP that Modern Humans spread into Europe (Grün *et al.*, 2005; Mercier and Valladas, 1994; Schwarcz *et al.*, 1998; Vandermeersch, 1982). The level of interaction between these two distinct groups of hominins has sparked lively debate, including whether Neanderthals actively contributed to the living human gene pool (see Chapter 4). While some consider Neanderthals and Early Modern Humans to be separate species, others maintain that they both form part of a larger group, encompassed by the term *Homo sapiens*. Throughout this thesis Neanderthals and Early Modern Humans will be viewed as two morphologically distinct groups of hominin.

Climate

The Neanderthal occupation of Eurasia spans several major climatic events and incorporates Marine Isotope Stages (MIS) 7, 6, 5, 4, and 3. During this time the earth's climate was subject to dramatic changes in temperature and much of this period, known as the Middle Palaeolithic, was relatively cold (Marean and Assefa, 1999). The beginning of this period (MIS 7) was mainly temperate and cool with a warm interglacial peak, leading on to full glacial conditions (MIS 6) (Stringer and Gamble, 1993). The last interglacial (MIS 5) was relatively warm but became temperate and cool, ending with the onset of full glacial conditions in Eurasia (MIS 4). The end of the Middle

Palaeolithic and the beginning of the Upper Palaeolithic (MIS 3), however, presented more variable conditions that fluctuated between cold and dry, and warm and wet (Bar-Yosef, 2000).

Climate appears to have greatly influenced the location of Neanderthal sites, with some areas becoming deserted during the maximum cooling phases and other areas, with favourable microclimates, acting as refuge zones maintaining a constant hominin presence (Patou-Mathis, 2000). The exceptionally warm MIS 5e, for example, played an important role in the eastern extension of the Neanderthals, allowing them to occupy territories between the Ural Mountains and the Caspian depression, and eventually parts of Central Asia (Hublin, 1998). MIS 4 also marked the major extension of Neanderthals into parts of Western Asia (Schwarcz *et al.*, 1989; Trinkaus, 1978a; Valladas *et al.*, 1999), although revised dates for Tabun C1 suggest an even earlier presence in this area during MIS 5 (Grün and Stringer, 2000).

Flora

Plants are an important resource in most modern hunter-gatherer populations, playing an important role in shaping social organisation, diets and mobility patterns (Madella *et al.*, 2002). Unfortunately the limited amount of plant remains discovered at Neanderthal habitation sites greatly limits direct evidence for, and our understanding of their role within these societies (Madella *et al.*, 2002). This lack of data has frequently been explained as a consequence of poor preservation of organic materials, but may also relate to the excavation methods used at many of the sites during the end of the 19th and beginning of the 20th centuries.

During more recent excavations at sites, such as Amud and Kebara in Israel and Vanguard and Gorham's Caves in Gibraltar, excavators were able to retrieve samples of plant remains (Gale and Carruthers, 2000; Lev *et al.*, 2005; Madella *et al.*, 2002). These discoveries provide us with an important insight into the use of plant remains by Neanderthals. Trees and shrubs appear to have been used as fuel for fires and as bedding at Amud Cave (Madella *et al.*, 2002). An abundance of charred legume seeds at Kebara strongly suggests that they made a substantial contribution to the diet of its inhabitants (Lev *et al.*, 2005). Analyses of charcoal samples and charred macrofossils from Gorham's and Vanguard Caves also revealed the presence of large numbers of pine (*Pinus*) nutshells and nutshell fragments (Gale and Carruthers, 2000). Gale and

Carruthers (2000) suggested that fire might have been used to open the cones for consumption purposes.

The availability of plant resources would have varied greatly between different regions within the Neanderthal home range, especially between north and south. Many sites would have been surrounded by an abundant supply of plant materials and it therefore seems likely that the residents would have exploited these resources. However, recent studies of stable isotope levels in Neanderthals suggest that the overwhelming majority of their dietary protein came from animal, rather than plant, sources (Bocherens *et al.*, 1991;Drucker and Bocherens, 2004;Fizet *et al.*, 1995;Richards *et al.*, 2000). Plants may not have always played an important role in the Neanderthal diet, but most likely would have formed an important resource for fuel, bedding and as a raw material for tools.

Non-human fauna

There can be little doubt that non-human fauna played an extensive role in the lives and diets of the Neanderthals; remains have been found in abundance at many sites throughout Eurasia, such as La Quina, Combe Grenal, Kebara and Tabun (Chase, 1986;Chase *et al.*, 1994;Davis, 1977;Garrod and Bate, 1937). The remains of medium and large-sized terrestrial herbivores and carnivores dominated these faunal assemblages, but the range of species varied between site and region (Patou-Mathis, 2000). Sites in the centre of the Neanderthal home range (central and eastern Europe), for example, were dominated by the remains of carnivores, such as cave lion (*Panthera leo spelaea*), leopard (*Panthera pardus*), wolf (*Canis lupus*) and hyaena (*Crocota crocuta*), unlike those on its peripheries (western Europe and the Middle East), which were dominated by terrestrial herbivores (Stringer and Gamble, 1993).

While the remains of carnivores are thought to provide evidence for their intermittent occupation of Neanderthal sites, terrestrial herbivores were thought to have directly contributed to the Neanderthal diet. Those most commonly found at Neanderthal sites were: horse (*Equus* sp.), woolly mammoth (*Mammuthus primigenius*), red deer (*Cervus elaphus*), bison (*Bison priscus*), ibex (*Capra ibex*), reindeer (*Rangifer tarandus*) and woolly rhinoceros (*Coelodonta antiquitatis*) (Chase *et al.*, 1994;Delpech, 1984;Marean and Assefa, 1999;Rabinovich and Hovers, 2004;Tchernov, 1998). Except for red deer and rhinoceros, these animals were all typical of cold climates and open environments (Hoffecker, 2002;Patou-Mathis, 2000). While a large diversity of non-human fauna

surrounded the Neanderthal sites, many assemblages showed a pattern of single species domination (Marean and Assefa, 1999).

Subsistence strategies

Evidence from stable isotopes, faunal remains and the palaeopathology of the skeleton suggests that, in general, Neanderthals consumed a low diversity diet centred on medium and large-sized terrestrial herbivores that migrated seasonally, although this would have varied regionally depending on the resources available, particularly between north and south (Bocherens *et al.*, 1991;Drucker and Bocherens, 2004;Hockett and Haws, 2005;Richards *et al.*, 2001). The efficient hunting of medium and large-sized game had previously only been attributed to modern humans, while Neanderthals were allocated the role of marginal scavengers (Binford, 1984). More recently, faunal studies have shown a very different picture, that in fact there were very few differences between Neanderthals' and early Upper Palaeolithic Modern Humans' hunting strategies (Grayson and Delpech, 2002).

By the beginning of the Middle Palaeolithic, hominin groups were able to apply diverse techniques for acquiring meat, often preferentially hunting a single species of medium and large-sized game (for a list of these species see above) (Finlayson, 2004;Marean and Assefa, 1999;Patou-Mathis, 2000). These animals appear to have been selectively killed according to age, sex, size and behaviour (Patou-Mathis, 2000). Seasonal hunting and recurring patterns of site occupation also underline the mobility of the Neanderthals' settlement system within large hunting territories (Patou-Mathis, 2000). Neanderthal skeletal remains also provide evidence of an active, hunting lifestyle with a high incidence of traumatic lesions, mostly associated with close-quarter hunting and possible inter-personal violence (see below).

The Neanderthals' ability to hunt does not mean that they did not scavenge food, as this could have been essential to their survival during periods of shortage (Finlayson, 2004). Indeed, scavenging by Neanderthals has been clearly established, indicating that they knew how to manage during these shortage periods (Patou-Mathis, 2000). For those Neanderthals who inhabited temperate and cold regions regular meat acquisition would have been even more important; many of these regions were subject to prolonged periods of cold when plant foods would have been unavailable for harvesting and consumption (Marean and Assefa, 1999).

3.2 Tool technologies

Neanderthals have most commonly been associated with Middle Palaeolithic tool industries, often referred to in Europe and Western Asia as the Mousterian. During the beginning of the Upper Palaeolithic c.45,000-30,000 BP, and towards the end of the period when Neanderthal remains can be identified in the fossil record, transitional industries, containing elements of both Upper Palaeolithic and Middle Palaeolithic tool industries, have been discovered at some Neanderthal sites.

Middle Palaeolithic industries

During the Middle Palaeolithic, c. 250,000–40,000 BP, there was a gradual shift in tool technology away from the large hand axes and cleavers of the Acheulean towards smaller tools made on flakes (Schick and Toth, 1993). These industries were dominated by flake-based lithic assemblages, which were typically produced from prepared cores, such as Levallois, and disc cores. There was quite a lot of variability in tool form, with scrapers common in some, and denticulates, unifacial points and bifacial points in others (Schick and Toth, 1993). Figure 3.1.1 shows an example of a collection of Middle Palaeolithic stone artefacts from Kebara cave, in Israel (Bar-Yosef, 2000).

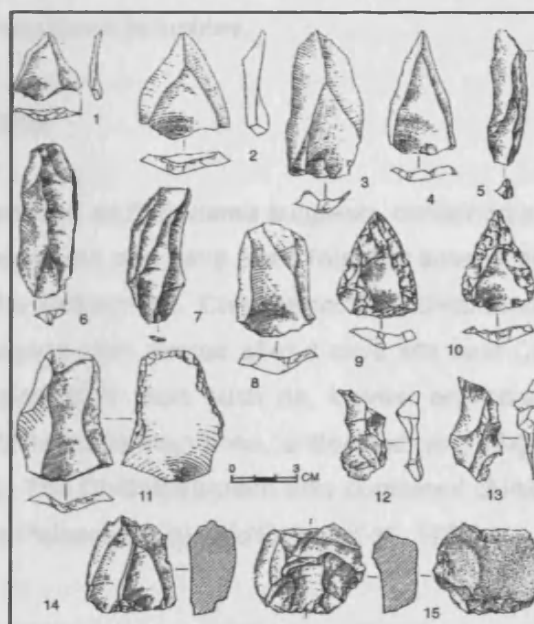


Figure 3.1.1: Middle Palaeolithic artefacts from Kebara cave in Israel, taken from Bar-Yosef (2000).

A large amount of variability existed within the Middle Palaeolithic toolkit. This variation was thought to reflect the effects of raw materials availability, the intensity of tool reduction (the modification of a tool using retouch) and their utilisation, rather than significant differences in tool industries (Dibble and Mellars, 1992; Patou-Mathis, 2000). Sites where local raw materials were plentiful, of good quality and large in size, for example, possessed assemblages that were composed of a large number of blanks, cores and bifaces but that contained few tools (Dibble and Mellars, 1992).

Despite these regional variations, the Middle Palaeolithic is viewed as a period of limited technological change, with the majority of retouched tools lacking any evidence of imposed form for non-functional, symbolic requirements (as seen in the Upper Palaeolithic) (Mellars, 2000). The overall morphological patterning of Middle Palaeolithic tool forms are also much simpler than those documented for Upper Palaeolithic industries, showing limited use of bone, antler or ivory (Mellars, 1989a; Patou-Mathis, 2000). After approximately 40,000 BP, Early Modern Humans were found in association with the more specialised Upper Palaeolithic industry based on blade production and including bone, ivory and antler tools, personal ornamentation and art. At this time some of the latest surviving Neanderthals, such as those from Saint-Césaire, Vindija G1, and Zafarraya (Hublin *et al.*, 1995; Mercier *et al.*, 1991; Smith *et al.*, 1999), have been associated with different types of tool industries, which have become known as transitional industries.

Transitional industries

Transitional tool industries, as their name suggests, contained a mixture of Middle and Upper Palaeolithic elements and have been found at several sites in Europe. These industries include the Bohunician, Châtelperronian, Jerzmanovician, Szeletian and Uluzzian. The Châtelperronian, named after a cave site near Châtelperron in France, contained Upper Palaeolithic tools such as, knives, end-scrapers, burins and fine blades, as well artefacts made from bone, antler and ivory (Fig. 3.1.2) (d'Errico *et al.*, 1998; Harrold, 1989). The Châtelperronian also contained at least 50% flaked tools of Mousterian or Middle Palaeolithic type (d'Errico *et al.*, 1998).

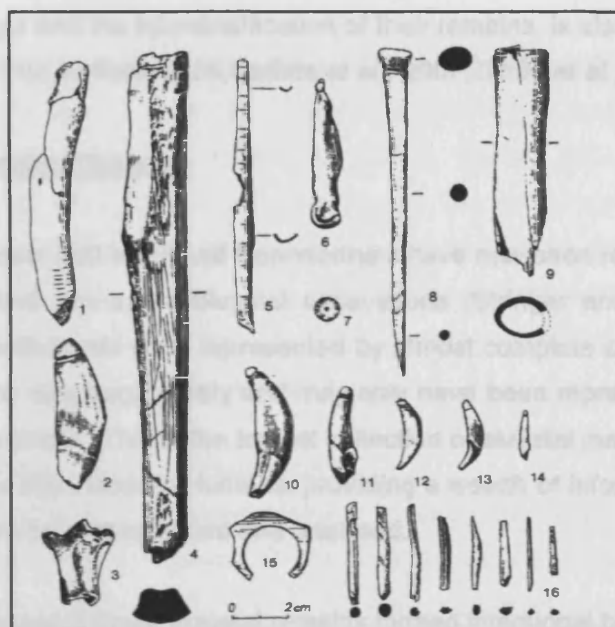


Figure 3.1.2: A collection of bone and ivory Châtelperronian tools and personal ornaments, taken from d'Errico *et al.* (1998).

The Uluzzian techno-complex, dated to approximately 31,000 BP, was unique to Italy and represents another transitional industry that contained a variety of end scrapers, side scrapers, curve backed blades, and denticulates, but classic Upper Palaeolithic blades were rare (Kuhn and Bietti, 2000). Bone tools were also present at some sites, but overall the assemblages attested to the absence of an Aurignacian influence, both technologically and typologically (Kuhn and Bietti, 2000). In central Europe transitional industries, known as the Bohunian and Szeletian, were discovered; a predominantly Levallois blade based and leaf point based industry, respectively (Kozłowski, 2000; Valoch, 2000). The Szeletian leaf points were manufactured using an Upper Palaeolithic bifacial tool-shaping technique, while the other tools were made from flakes using a Middle Palaeolithic discoidal core technique. This industry disappeared from the archaeological record approximately 35,000 years BP with no evidence for continuation (Kozłowski, 2000).

Neanderthals have been either directly or in-directly associated with all of these transitional industries, but much debate has surrounded whether the Upper Palaeolithic elements were copied, borrowed or represented an isolated development from that of Upper Palaeolithic Modern Humans (d'Errico *et al.*, 1998; Mellars, 2000; Zilhão *et al.*, 2006). The level of interaction between Neanderthals and Upper Palaeolithic Modern

Humans in Europe and the interstratification of their remains, is also widely debated (Gravina *et al.*, 2005; Mellars, 2006; Mellars *et al.*, 2007; Zilhão *et al.*, 2006).

3.3 The Neanderthal Skeleton

The remains of over 500 individual Neanderthals have now been recovered from both archaeological and non-archaeological excavations (Stringer and Andrews, 2005). Some of these individuals were represented by almost complete or partial skeletons, while others were very fragmentary and may only have been represented by a single tooth or bone fragment. This is the largest collection of skeletal material for any group of hominin, other than Modern Humans, providing a wealth of information from which their anatomy can be reconstructed and analysed.

Whether or not some of these skeletal remains formed intentional burials has been the subject of an intense debate. Despite severe criticism (Gargett, 1989; Gargett, 2000), it appears that at least some Neanderthals were burying their dead (Hovers *et al.*, 1995; Hovers *et al.*, 2000). The number of known Neanderthal burials have ranged in estimate from around 30 (Harrold, 1980) to around 60 (Smimov, 1989), and appeared from at least 70,000 years BP (Defleur, 1993), and possibly even earlier during MIS 5 or MIS 6 (Tabun C1) (Grün and Stringer, 2000).

Crania

Neanderthals have been noted, since their first discovery, for their large cranial capacities. Their large skulls were long and flattened, creating an occipital bun (a prominent bulge of the occipital bone) and a suprainiac fossa (an elliptic depression located above the nuchal line) at the back of the head. The face was dominated by large brow ridges and a large nasal cavity with a protruding midfacial region and swept back zygomatic arches (Churchill, 1998; Rak, 1986; Trinkaus, 1987b). The mandible was chinless with a gap between the third molar and anterior edge of the ascending ramus, known as the retromolar space (Churchill, 1998). The anterior teeth were relatively large compared with the cheek teeth, and possessed enlarged lingual tubercles, pronounced shovelling (prominent marginal ridges) in the maxillary incisors and strong labial curvature, as well as often being heavily worn (Bailey, 2002; Molnar, 1972; Puech, 1981; Tillier *et al.*, 1995; Ungar *et al.*, 1997). The cheek teeth often possessed enlarged pulp cavities caused by taurodont roots (Stringer and Gamble, 1993).

While several of these features were present in the assumed Neanderthal ancestor, *Homo heidelbergensis*, the collective craniofacial morphology is widely believed to be unique in the genus *Homo* (O'Connor *et al.*, 2005). Debate still continues about the precise anatomical basis for this uniqueness and the evolutionary mechanism that produced it. Explanations have included adaptation to the cold (Coon, 1962), random genetic drift (Howell, 1951; Hublin, 1998), altered growth patterns (Ponce de León and Zollikofer, 2001; Smith, 1991a) and respiratory moisture retention in cold and/or arid conditions (Franciscus and Trinkaus, 1988).

The Anterior Dental Loading Hypothesis

Another explanation for the Neanderthals' unique cranio-facial morphology is the 'Anterior Dental Loading Hypothesis'. This theory maintains that the Neanderthal facial morphology was an adaptive response to the high magnitude of forces resulting from both the masticatory and cultural use of the teeth (Brace, 1995; Demes, 1987; Rak, 1986; Smith, 1983). Rak (1986) suggests that the Neanderthal facial morphology was the result of rotational forces from the heavy loadings on the anterior teeth and this work has been supported by Demes (1987). The relatively large size of the anterior teeth and the severity of tooth wear in Neanderthal specimens have also been used as strong support for this theory (Demes, 1987; Rak, 1986; Smith, 1983; Smith, 1976b). Opponents of this theory, however, suggest that the Neanderthal masticatory system was actually disadvantageous for producing large bite forces and that the heavy wear seen in the anterior dentition was most likely due to the repetitive usage of these teeth (Antón, 1990; Antón, 1994; O'Connor *et al.*, 2005).

Post-crania

The bodies of Neanderthals were relatively short and strongly built with large, barrel-shaped chests and short, muscular limbs (Churchill, 1998; Holliday, 1997b; Stringer and Gamble, 1993). Their bones were strongly built with large elbow, hip and knee joints, and their muscles often left marks of deep or wide attachment areas on the bones (Stringer and Gamble, 1993). Neanderthals possessed wide pelvic bones with elongated and slender pubic rami. It has been suggested that this would have increased the volume of the birth canal and therefore the size of newborn babies (Trinkaus, 1984a), but may have simply been connected to their locomotion (Klein, 1999).

The distinctive post-cranial morphology, and parts of the cranial morphology of Neanderthals, have commonly been viewed as adaptations to the cold conditions of glacial Europe (Brose and Wolpoff, 1971; Franciscus and Trinkaus, 1988; Holliday, 1997b; Ruff, 1994; Stringer and Gamble, 1993). The Neanderthal body shape of long trunks, large femoral heads and short limbs (especially distal segments), was shown to be similar to that of a recent Inuit group from Alaska (Holliday, 1997b). In fact, the Neanderthals possessed a more extreme, cold adapted body shape than the Alaskan Inuit. Cold-adaptation does not, however, account for all of the Neanderthals' distinctive features that distinguish them from Modern Humans; the robusticity of their bones, the shapes and orientations of their muscle attachments and limb joints. These can only be indirectly related to cold climates and are directly related to an active lifestyle (Churchill, 1998; Schmitt and Churchill, 2003). It is also worth remembering that the Neanderthals lived through warmer periods in Europe and ranged across the warmer climates of Western Asia into the present day countries of Iraq, Syria, Israel, Georgia, Russia, the Ukraine and as far as Uzbekistan.

The robusticity of the Neanderthal post-cranial skeleton suggests that their bodies were well-adapted to generating and withstanding large forces (Churchill and Rhodes, 2006). The size of muscle attachment sites and the mechanical advantage of the upper limbs in Neanderthals indicates pronounced upper body strength compared to that of Modern Humans (Churchill and Rhodes, 2006). Neanderthal skeletons are also characterised by high levels of bilateral strength asymmetry of the humerus (especially seen in males) (Churchill *et al.*, 1996; Trinkaus *et al.*, 1994). The humeral shafts tend to be rounder in cross-section than found in Modern Humans, and the right humeri are generally more robust than the left (Churchill *et al.*, 1996). These features have been associated with projectile spear hunting, with the thrusting of the spear one of the principal causes (Churchill and Rhodes, 2006; Gainor *et al.*, 1980; Schmitt and Churchill, 2003). Close-quarter hunting has also been associated with a high incidence of skeletal trauma in the Neanderthal skeleton.

Skeletal trauma

Healed traumatic lesions are commonly found in well-preserved Neanderthal skeletons, occurring in the partial skeletons of individuals between 25 and 30 years of age by modern day standards (Berger and Trinkaus, 1995; Brennan, 1991; Trinkaus, 1983b). Some of these lesions appear to represent severe injuries that could have substantially limited the use of a particular limb. These traumatic injuries are present in both male

and female Neanderthals, but for those whose sex can be determined, 85.7 % of head and neck injuries are in males, indicating that some form of sexual division of labour may have existed (Berger and Trinkaus, 1995) or male/female differences in inter-personal violence.

It has been well-documented that Neanderthals were actively hunting prime-aged, medium-sized ungulates, and often have faunal assemblages dominated by single prey species (Chase, 1986;Farizy, 1994;Stiner, 1992a;Stiner, 1992b;Stiner, 1994). Berger and Trinkaus (1995) identified a high incidence of head and neck injuries in Neanderthals and compared this distribution of traumatic lesions with more modern populations and, intriguingly, the best fit has been a group of North American rodeo riders. Given the close-range of the hunting spears used by the Neanderthals, and the tendency of terrestrial herbivores to react strongly when being hunted, the high number of these injuries does not seem surprising.

Evidence for inter-personal violence amongst Neanderthals has also been found in their skeletons: Shanidar 3 suffered an injury to the ninth left rib indicative of a penetrating implement, found *in situ* between the neighbouring ribs (Berger and Trinkaus, 1995;Trinkaus, 1983b); a young adult from Saint-Césaire also showed evidence of a healed trauma on its cranial vault, the size and shape of which suggests it was the result of an impact from a sharp implement (Zollikofer *et al.*, 2002).

Some Neanderthal skeletons display not only a particularly large number of healed traumatic lesions, but also evidence of widespread joint disease, which suggest that the affected individuals could not have existed without assistance from those around them. The individual from La Chapelle-aux-Saints, for example, appears to have suffered from degenerative joint disease in his vertebrae and hip joints, may have been blind in his left eye, appears to have been partly paralysed down one side, had a withered handless right arm and had lost most of his teeth (Trinkaus, 1985b). Despite these disabilities it appears that he lived until late adulthood, suggesting that he was being cared for by one or several members of his group (Trinkaus, 1985b).

Tooth Wear

Neanderthal teeth have distinctive morphologies (see above) and many of these features, such as labial curvature and pronounced shovelling, have been linked with masticatory stress. This is supported by the extreme patterns of wear frequently

documented in Neanderthal teeth (Bax and Ungar, 1999; Bermúdez de Castro *et al.*, 1988; Lalueza *et al.*, 1996; Molnar, 1972; Puech, 1981; Ungar *et al.*, 1997; Wallace, 1975), as well as a high incidence of chipping, fracturing and *ante-mortem* tooth loss (Fox and Frayer, 1997; Puech, 1981; Tappen, 1985; Tillier *et al.*, 1995).

Micro-wear studies, such as that by Fox and Pérez-Pérez (1993), show that Neanderthals were consuming a highly abrasive, largely carnivorous diet. An abrasive diet cannot, however, account for all of the wear seen within the dentition. The Neanderthal pattern of heavy wear has frequently been compared to that of modern hunter-gatherer groups, such as the Greenland Inuit who use their teeth as tools for tasks such as softening raw seal-hide (Bax and Ungar, 1999). Molnar (1972) noted that Neanderthal incisors and canines exhibit heavier wear than their molars, which are, in contrast, relatively unworn. This is similar to the pattern reported in Inuit, and it has therefore been proposed that Neanderthals used their teeth in very similar ways (Ungar *et al.*, 1997). The distinctive morphology of the Neanderthal skull has also been cited as an adaptive response to the large forces being placed on the dentition (see above).

Reports on Neanderthal tooth wear have generally centred around three major issues. The first is the occurrence of striations on the labial surfaces of the anterior teeth, thought to be caused by stone tools when slicing material gripped between the front teeth and/or grit in their diet (Bax and Ungar, 1999; Bermúdez de Castro *et al.*, 1988; Brace, 1975; Fox and Frayer, 1997; Lalueza *et al.*, 1996). The second is the appearance of linear grooves on the inter-proximal surfaces at the cervix of the teeth, known as interproximal grooves (IPGs). A lively debate has surrounded the determination of the causes of these grooves. Suggestions for the causes of IPGs include the sucking of dietary grit through the teeth, the insertion of toothpicks between teeth and the pulling back and forth of organic matter between teeth (Bermúdez de Castro and Pérez, 1986; Brothwell, 1963; Formicola, 1988b; Frayer, 1991; Frayer and Russell, 1987; Hlusko, 2003; Ubelaker *et al.*, 1969; Wallace, 1974). The third issue is the presence of bevelling/rounding on the labial (lip) surfaces of many Neanderthal incisors (Bax and Ungar, 1999; Brace, 1962; Brace, 1975; Coon, 1962; Fraipont and Lohest, 1887; Lebel *et al.*, 2001; Ungar *et al.*, 1997). Most recent research suggests that this incisor bevelling/rounding was the product of increased levels of use of these teeth during both masticatory and non-masticatory activities (Ungar *et al.*, 1997).

Tooth wear has only be examined in detail in three Neanderthals: La Ferrassie (Puech, 1979;Puech, 1981), Gibraltar 1 (Clement, 2000) and Shanidar 1 (Trinkaus, 1983b). La Ferrassie 1 possessed extreme tooth wear with many of the teeth worn down to stumps. Puech (1979;1981) proposed that the asymmetry of this wear was caused by their regular use for tasks that were not directly related to the modification of food (for a detailed description see Chapter 7.1). Heavy tooth wear has also been noted in the Gibraltar 1 specimen from Forbes Quarry and includes: a high frequency of enamel chipping and fracturing; rounding of the incisors; an IPG on the upper right second molar; and the antemortem loss of the upper first molars (Clement, 2000). These features have been attributed to a highly abrasive marine and carnivorous diet, as well as the non-masticatory use of the teeth in functions such as clamping, holding, gripping and the cracking of hard objects such as mussels (Clement, 2000). The dentition of Shanidar I has been noted for its unusual wear patterns, exhibiting particularly heavily worn canines and incisors. This wear is not simply present on the occlusal surfaces of these teeth, but continues onto the labial surfaces. Molnar (1972) attributes this to the holding of objects between the teeth in possible compensation for a damaged arm.

While interesting and detailed, these more in-depth studies of tooth wear in La Ferrassie I, Gibraltar I and Shanidar I are of little use in comparative studies as they are mostly descriptive and lacking any form of standardisation. This is also true of reports on tooth wear features such as IPGs and buccal striations. Such reports demonstrate the need for a more comprehensive and standardised approach to the study of tooth wear patterns in Neanderthals and other hominin groups.

3.4 The fate of the Neanderthals

The disappearance of the Neanderthals from the fossil record approximately 30,000 BP has led to the creation of numerous alternative explanations. There are two main schools of thought: the first is that many Neanderthal populations were subsumed within the populations of Anatomically Modern Humans; and the second is that they were driven to extinction.

The most popular extinction theory involves Modern Humans as the main culprit, driving Neanderthals to extinction through direct or indirect competition (Bocquet-Appel and Demars, 2000;Klein, 2000;Mellars, 1989b;Pettitt, 1999;Pike-Tay *et al.*, 1999). An alternative explanation is that Neanderthals were driven to extinction by climatic and environmental factors alone (Finlayson *et al.*, 2000;Leroyer, 1988;Leroyer and Leroi-

Gourhan, 1983;Stewart *et al.*, 2003;Stewart, 2004). Modern Humans, with their greater dietary breadth and resource base, may have avoided the pressures of climatic change by diversifying (Stewart, 2004).

The disappearance of Neanderthals may well have been the result of a combination of these factors, but whatever the cause the skeletal evidence for Neanderthals disappears from the fossil record around approximately 30,000 BP, in what appears to be their last refuge, south-west Europe.

3.5 Summary

Neanderthals formed a morphologically distinct group of hominins who successfully inhabited parts of Eurasia for over 200,000 years, from areas as far west as France and as far east as Uzbekistan. These strongly built individuals appear to have lived a highly-active lifestyle, subsisting mainly on medium to large-sized game, during a relatively cold time period. They employed specialised hunting techniques, often focusing on one or two species of animal, using close-range hunting technology accompanied by a generalised Mousterian tool kit, which included the Neanderthal dentition. The very end of the Neanderthal era witnessed a major change in their behaviour with the appearance of transitional technologies at some sites. These new industries combined more specialised tools such as knives and burins, as well as personal ornamentation and the widespread use of bone, ivory and antler with the more traditional Middle Palaeolithic elements. Intriguingly, this is quickly followed by the complete disappearance of the Neanderthals from the fossil and archaeological record.

Attempts to generalise about the Neanderthals may mask local and chronological adaptations and changes in behaviours. Indeed, a range of behaviours have been shown at many different sites, and it is important to view this group of hominins relative to the sites in which they lived and their different geographical surroundings (see Chapter 7.1).

Chapter 4: The Emergence of Early Modern Humans and Beyond

Recent dating evidence has shown that both Neanderthals and Early Modern Humans inhabited the landscape of Middle and Early Upper Palaeolithic Western Eurasia. The biological and cultural interactions between these two groups have been the object of a long intense debate (Farizy, 1994;Frayer *et al.*, 1993;Gargett, 1989;Harrold, 1989;Lieberman and Shea, 1994;Mellars, 1989c;Mellars, 2000;Stoneking, 1993;Stringer and Andrews, 1988). Ultimately the morphologically distinct Neanderthals disappeared from the fossil record approximately 30,000 BP leaving behind a single group of hominins: *Homo sapiens*. Groups of Modern Human hunter-gatherers continued to occupy parts of Eurasia throughout the Upper Palaeolithic, becoming more complex in their behaviour during the Late Epipalaeolithic and Mesolithic, culminating in the adoption of agriculture during the Neolithic.

4.1 Modern human origins

Since the 1980s the debate about the origins of modern humans has dominated the field of palaeoanthropology. Several contrasting models have been proposed, of which the most polarised are the multi-regional hypothesis and the 'Out-of-Africa' hypothesis. The multi-regional hypothesis (Frayer *et al.*, 1993;Frayer *et al.*, 1994;Thorne and Wolpoff, 1992) views all hominins, from *Homo erectus* to *Homo sapiens*, as a single species, with natural variations developing as a result of geographic isolation. The 'Out-of-Africa' or single origin hypothesis (Stringer, 1990;Stringer and Andrews, 1988) proposes that modern humans evolved in eastern or sub-Saharan Africa and migrated to the rest of the world, replacing groups of archaic humans. It does not dismiss the possibility of some interbreeding, but argues that this did not make any significant genetic contribution to modern day humans. It often proposes that Neanderthals and modern humans represent different species.

These opposing hypotheses represent the ends of a spectrum that contains many variations (Aiello, 1993;Relethford, 1995;Relethford, 1999;Smith *et al.*, 2005;Weiss, 1988). The hybridisation hypothesis (Bräuer, 1992), acknowledges the African origin of modern humans, but includes hybridisation and gene flow with archaic populations, leading to their eventual replacement. The assimilation hypothesis envisages gene

flow and population admixture having an even larger impact on the maintenance of regional traits through to modern geographic populations (Smith, 1994; Trinkaus, 1986).

Genetics provides an alternative source of evidence in determining the origins of Modern Humans. It has been used to strongly support some forms of the 'Out of Africa' hypothesis (Cann *et al.*, 1987; Goldstein *et al.*, 1995; Stoneking, 1994; Stringer and Andrews, 1988; Templeton, 1993; Templeton, 1994; Tishkoff, 1996; Wilson and Cann, 1992). The evidence collectively proposes a divergence date of 200-100,000 BP for the emergence of Modern Humans in Africa. Studies of fossil Neanderthal DNA indicate their genetic distinctness, when compared to present-day Modern Humans, and suggests a common ancestor c. 465,000 BP (Caramelli *et al.*, 2003; Krings *et al.*, 2000; Ovchinnikov *et al.*, 2000; Scholz *et al.*, 2000).

The anatomical evidence also demonstrates distinct differences between Neanderthals and Modern humans. When compared to Modern Humans, Neanderthal crania possess relatively large supra-orbital ridges (brow ridges), occipital buns (arguably not found in modern humans), a large nasal aperture, swept-back zygomatic arches, chinless jaws with retromolar spaces and midfacially prognathic faces (Churchill, 1998). The post-cranial skeleton is more robust than in the more gracile Modern Human skeleton, with long clavicles, broad scapulae and stout lower limb bones with an enlarged rib cage and an elongated pelvis (Churchill, 1998).

The debate continues and while there is no proven biological reason why Neanderthals and Modern Humans could not have interbred, recent genetic evidence suggests that Neanderthal genes are not present in modern populations (Caramelli *et al.*, 2003; Krings *et al.*, 2000; Ovchinnikov *et al.*, 2000). When the genetic evidence is combined with the anatomical and archaeological data there is little doubt that Neanderthals represent a separate lineage in human evolution.

4.2 Middle Palaeolithic Modern Humans

Early Modern Humans appear in the archaeological record from about 200,000 BP in parts of Africa, from about 100,000 BP in Western Asia and from 40,000 BP in Europe. The Early Modern Humans in Western Asia used tool industries similar to those associated with Neanderthals from this area (Bar-Yosef *et al.*, 1992; Bar-Yosef, 1998; 2000; Bräuer, 1984; Rightmire, 1984; Vandermeersch, 1981). In Europe, where they appeared later, they were associated with Upper Palaeolithic technologies.

Qafzeh and Skhul

In Western Asia two Early Modern Human populations, dating to the Middle Palaeolithic, were discovered at the sites of Qafzeh and Skhul, Israel (McCown, 1937;Neuville, 1951;Vandermeersch, 1981). Several populations of Neanderthals have also been discovered in this region at the sites of Amud, Kebara, Tabun and Shanidar (Bar-Yosef *et al.*, 1992;Garrod and Bate, 1937;Suzuki and Takai, 1970;Trinkaus, 1983b). Their phylogenetic relationship with the Qafzeh and Skhul Modern Humans has been widely debated (Bar-Yosef and Vandermeersch, 1981;McDermott *et al.*, 1993;Mercier and Valladas, 1994;Schwarcz *et al.*, 1998;Trinkaus, 1992;Valladas *et al.*, 1988). Originally the Neanderthal fossils were seen as the likely progenitors of the Early Modern Humans from Qafzeh and Skhul (Jelinek, 1982b;Trinkaus, 1984b;Trinkaus, 1986). However, the microfaunal analysis of the hominin bearing layers at Qafzeh and Skhul had long suggested their greater antiquity than the Neanderthal sites (Bar-Yosef and Vandermeersch, 1981), which was finally confirmed through a series of new ESR and TL dates of c. 130-90,000 BP, thus making the Neanderthal to modern human lineage impossible (Grün *et al.*, 2005;McDermott *et al.*, 1993;Mercier *et al.*, 1993;Schwarcz *et al.*, 1988;Stringer *et al.*, 1989;Valladas *et al.*, 1988;Yokoyama *et al.*, 1997).

Environment

Early Modern Humans appeared in Western Asia during the Last Interglacial (MIS stage 5). The associated non-human faunal assemblages from Qafzeh and Skhul included high numbers of red deer (*Cervus elaphus*), as well as fallow deer (*Dama mesopotamica*), aurochs (*Bos primigenius*) and gazelle (*Gazella* sp.) (for a more detailed list see Chapter 7.2) (Bouchud, 1974). This list of species was comparable to those found at the neighbouring Neanderthal sites (Chapter 7.1).

Tool industries

The Middle Palaeolithic stone tool assemblages from Qafzeh and Skhul were made using a Levallois technique typified by large oval flakes, scrapers (racloirs) and a low proportion of points. The industry resembles the Levallois Mousterian from Tabun C (Garrod and Bate, 1937;Jelinek, 1982b;Shea, 1989). Comparisons of the tool industry from Qafzeh Cave with that from the later Tabun B type industry at the Middle Palaeolithic site of Kebara Cave (which was occupied by Neanderthals) demonstrates that there were many similarities between the technological adaptations of the two

hominin populations in the region (Shea, 1989). Shea (1998) has, however, noticed a much higher proportion of Levallois points in the Neanderthal sites.

Hominin remains

Together, the caves of Qafzeh and Skhul have yielded the remains of over 30 hominins (Valladas *et al.*, 1987). Most features of their cranial morphology were similar to, but slightly more robust than those of Upper Palaeolithic Modern Humans, such as relatively high, short brain cases that overlapped the face below, the retraction of the face beneath the brain case, combined with the absence of a retromolar space in the mandible and the presence of a chin (Klein, 1999). The expression of many cranial features showed substantial variation within the group, such as in their expression of chins, vertical foreheads, rounded occipitals, parietal bossing, brow ridges and tooth size (Bräuer, 1989;Stringer, 1989;Trinkaus, 1984b). They also had a tendency towards pronounced alveolar prognathism which is in contrast to more archaic hominins, such as Neanderthals, who possessed mid-facial prognathism.

Their post-cranial skeletons appeared gracile, compared to the Neanderthals from the same region, but robust, particularly in their legs, when compared to Upper Palaeolithic Modern Humans (Klein, 1999;Trinkaus, 1983a). The decreased radial bowing in the upper limbs, compared to Neanderthals, suggested a major decrease in muscle development (Trinkaus, 1984b). Differences in thumb size and shape also suggested that these Early Modern Humans had a much less powerful grip than the Neanderthals (Klein, 1999).

They showed little to no change in the size of their cheek teeth, but a reduction in the size of the anterior teeth, with some overlap with the Neanderthals (Klein, 1999;Trinkaus, 1984b). Trinkaus (1984b) suggested that this decrease in anterior tooth dimensions was the result of a reduction in average levels of force and/or occlusal attrition placed on the anterior teeth. In addition, he suggested that Neanderthals were subjecting their anterior teeth to greater wear and stress than the Early Modern Humans of Qafzeh and Skhul. It has also been proposed that the anterior and cheek teeth wore at approximately the same rate among Middle Palaeolithic Modern Humans (McCown and Keith, 1939;Trinkaus, 1984b;Vandermeersch, 1981).

The Qafzeh and Skhul hominin skeletons showed little evidence of trauma, injury or physiological stress (Vandermeersch, 1981). Similarly, within their dentitions there was

no evidence of malocclusion, crowding, or abnormal spacing of teeth and dental disease was rare (Tillier *et al.*, 2004).

4.3 Upper Palaeolithic Modern Humans

In contrast to the Early Modern Humans from Western Asia, those found in Europe were associated with Upper Palaeolithic tool technologies and date to a much later period, 40/35,000 - 11,000 BP. This represents a gap of almost 70,000 years from when Early Modern Humans first migrated into Western Asia. Most Upper Palaeolithic industries are associated with Modern Humans, but recent evidence has also linked Neanderthals with some of the earliest Upper Palaeolithic traditions, known as the transitional industries, such the Châtelperronian, the Uluzzian and Szeletian (d'Errico *et al.*, 1998; Harrold, 1989; Kozłowski, 2000; Kuhn and Bietti, 2000) (see Chapter 3). The Upper Palaeolithic industry, associated with Early Modern Humans, has been divided into four main cultural traditions: the Aurignacian c.40/35-25,000 BP; Gravettian/Perigordian c.30-22,000 BP; Solutrean c.22-18,000 BP, and finally the Magdalenian c. 18-11,000 BP (Peregrine, 2001).

Environment

The Upper Palaeolithic represented a period of climatic fluctuations: beginning with interstadial periods and the retraction of the ice sheets and the expansion of grasslands and forests throughout Europe (Peregrine, 2001); followed by a major climatic change c. 20,000 BP, associated with the Last Glacial Maximum and the extension of the ice sheets from northern Europe down into central Europe (Roebroeks *et al.*, 2000); and ending with a period of warming (Simmons, 2004).

Upper Palaeolithic Modern Humans occupied a variety of sites, including caves, rock-shelters and open-air throughout the year, which appeared to have served a variety of functions, such as short-term butchery, hunting and lithic procurement sites, as well as larger more permanent sites (Pike-Tay, 2001). These sites were more common than those from the preceding Middle Palaeolithic and this has been interpreted as evidence for either increased population size and/or density (Pike-Tay, 2001).

Like their Middle Palaeolithic predecessors the Upper Palaeolithic Modern Humans hunted mainly medium to large sized game. The principal game hunted were woolly mammoths (*Mammuthus primigenius*), reindeer (*Rangifer tarandus*), red deer (*Cervus*

elaphus), roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*), bovids (*Bos* sp.), wild horse (*Equus caballus*), hare (*Lepus* sp.) and saiga antelope (*Saiga tatarica*) (Bouchud, 1975;Cheynier, 1965;St-Pèrier and St-Pèrier, 1952;Svoboda *et al.*, 2005). The types of game hunted varied between regions, with reindeer making up to 99% of the faunal assemblage from French Magdalenian sites (Bouchud, 1975). It has also been suggested that compared to their Middle Palaeolithic predecessors, Upper Palaeolithic modern humans were more specialised in their hunting practices, targeting one of two species of animals (Mellars, 1989b). However, evidence for this type of specialised hunting practice has also been found at Middle Palaeolithic sites, such as Combe-Grenal (Chase, 1986).

There was also a decrease in the numbers of large carnivores, such as wolf (*Canis lupus*), hyaena (*Hyaena* sp.), cave lion (*Panthera leo spelaea*), cave bear (*Ursus speleaus*) and brown bear (*Ursus arctos*), found in Upper Palaeolithic sites, which may reflect an increase in the intensity of site use by Upper Palaeolithic Modern Humans (Bouchud, 1975;St-Pèrier and St-Pèrier, 1952). Non-human faunal remains were also widely used in the production of tools and art objects, as well as dwelling structures, such as those found at Pavlov in the Czech Republic (Svoboda, 1991a;Svoboda, 1995;Svoboda *et al.*, 2005;Svoboda and Škrdlá, 1997).

In common with most Middle Palaeolithic sites, few plant remains have been retrieved from Upper Palaeolithic sites (Donner, 1975). A wide diversity of flora would have been available to Upper Palaeolithic Modern Humans and it therefore seems likely that they would have played an important role in both the diet and lifestyle of these Modern Humans. Their diet was also supplemented by shellfish, birds, fish and small game (Capitan and Peyrony, 1928;Cheynier, 1965;St-Pèrier and St-Pèrier, 1952).

Tool industries

The Upper Palaeolithic marked a major change in tool production towards a more specialised and flexible tool kit, with a new pattern of core preparation, allowing a more intensive production of standardised blades (Blades, 1999). The most characteristic Upper Palaeolithic tools were: burins, endscrapers, backed or truncated pieces and carinated or nosed scrapers (Fig. 4.3.1) (Blades, 1999;Kozłowski, 1990;Sonneville-Bordes and Perrot, 1956).

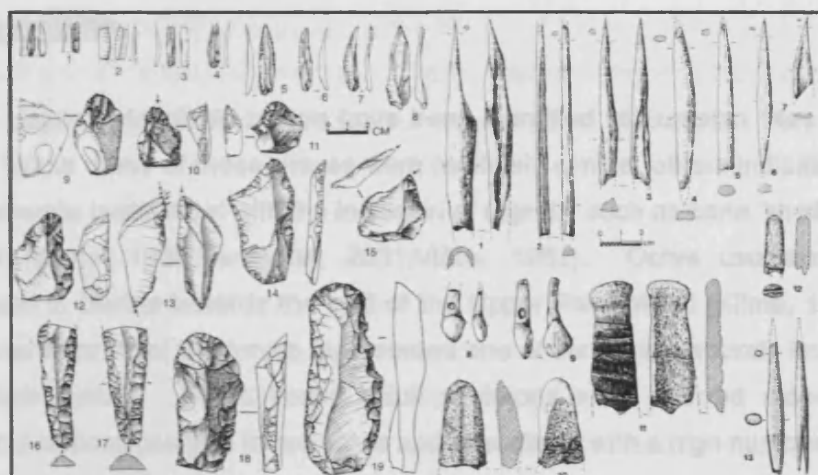


Figure 4.3.1: A collection of Upper Palaeolithic stone tools and bone, ivory and antler objects, taken from Mellars (2000).

In addition to stone, bone, ivory and antler were extensively used in the production of tools, such as awls, needles, projectile points, harpoons, spears and spear throwers (Fig. 4.3.1) (Blades, 1999; Clay, 1995; Mellars, 2000). Personal ornamentation, such as decorated pendants and beads, occurred in large quantities for the first time during the Upper Palaeolithic (Mellars, 2000; Svoboda, 1995). The Upper Palaeolithic also marked the appearance of complex and sophisticated representational art, symbolic expression and expanding distribution and trading networks (Cheynier, 1965; Mellars, 1989a; Svoboda *et al.*, 2000). Animal figurines carved from mammoth ivory were recovered from the early Upper Palaeolithic levels in the Vogelherd Cave, southern Germany dated to c. 30-34,000 BP (Fig. 4.3.2) (Mellars, 1989a).

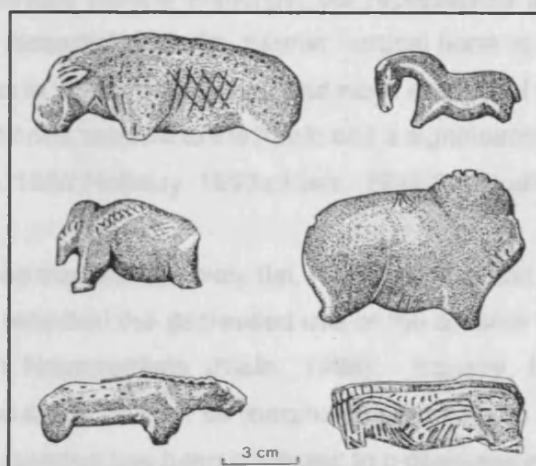


Figure 4.3.2: Animal figurines carved from mammoth ivory, recovered from the early Aurignacian levels in Vogelherd Cave, Southern Germany, taken from Mellars (1989a).

Hominin remains

Over 90 Upper Palaeolithic burials have been identified at Eurasian sites (Pike-Tay, 2001). While many of these graves were relatively simple, others indicated a much more elaborate burial ritual with the inclusion of objects, such as bone, shell and stone artefacts (Klíma, 1988;Peregrine, 2001;Vlček, 1962). Ochre use also became widespread in burials towards the end of the Upper Palaeolithic (Klíma, 1988). The triple burial from Dolní Věstonice represented one of the most elaborate known Upper Palaeolithic burials. Three young adult skeletons were interred side-by-side in extended positions covered in red ochre and associated with a high number of pierced animal teeth pendants (for more detail see Chapter 7.3) (Alt *et al.*, 1997). Many sites have also yielded the fragmentary remains of Upper Palaeolithic Modern Humans within their occupational layers (Billy, 1975;Ferembach, 1965;Joffroy and Mouton, 1946). Some of these fragments, such as those from the site of Le Placard in France, showed evidence of intentional cut marks and impact scars from stone implements (Breuil and Obermaier, 1909;Ferembach, 1965).

There was a wide diversity in the skeletal morphology of the Upper Palaeolithic Modern Humans, but some general similarities have been observed. Their crania possessed vertical frontal bones, high cranial vaults, greater brow ridge development in males than in females, relatively flat faces, canine fossae, robust mandibles with a distinctive chin and lacking a retromolar space (reflecting the retraction of the face) (Klein, 1999). Their post-cranial skeletons had more robust limb bones than more recent Modern Humans with pronounced muscle markings, but represented an overall decrease in robusticity from the Neanderthals with: thinner cortical bone in the femur and tibia; a shorter distal phalanx in the thumb; smaller and more elongated distal phalanges in the fingers; longer limb bones, relative to the trunk; and a significantly shorter pubis bone in the pelvis (Churchill, 1998;Holliday, 1997a;Klein, 1999;Shackelford, 2007).

It has been suggested that the relatively flat, retracted face and change in skull shape of modern humans, reflected the decreased use of the anterior teeth as tools, at least by comparison with Neanderthals (Klein, 1999). Equally, the overall decline in robusticity and muscularity, as well as morphological changes shown by the Modern Human post-cranial skeleton has been attributed to a decrease in the reliance on bodily strength in performing everyday tasks (Trinkaus, 1983a;1987a). Their African origin from a relatively warm climate may also have been responsible for their relatively long limbs and short trunks (Holliday, 1997a). The skeletal evidence from Europe

suggested that Modern Human bodily dimensions and robusticity continued to decline throughout the late Pleistocene (Fraye, 1984). Unlike Neanderthals skeletons, those of Upper Palaeolithic modern humans showed limited evidence for serious trauma (Klein, 1999).

Studies have shown that Upper Palaeolithic modern humans possessed larger dimensions for their teeth than Modern Humans from later cultural periods, such as the Mesolithic, but smaller dimensions than hominins from the Middle Palaeolithic (Fraye, 1978a;1984;Hillson and Fitzgerald, 2003;Smith, 1972;Smith *et al.*, 1984). This is associated with the general reduction in the robustness of the skull and facial skeleton over time (Hillson, 2005). Upper Palaeolithic modern humans also showed more sexual dimorphism in their tooth size than those from the Mesolithic (Klein, 1999).

4.4 Epipalaeolithic Modern Humans

The term Epipalaeolithic has been applied to late Palaeolithic cultural traditions around the Mediterranean Basin of Southern Europe, Western Asia and North Africa. In Western Asia, the Upper Palaeolithic is dated to c.45-22,000 BP (Emiran, Ahmarian, Levantine Aurignacian and Atlitian); the Early Epipalaeolithic c. 22,000-14,500 BP (Late Ahmarian, Kebaran and Nizzanan); the Middle Epipalaeolithic c. 14,500-12,500 BP (Geometric Kebaran); and the Late Epipalaeolithic c. 12,500-10,200 BP (Natufian) (Belfer-Cohen, 1991;Goring-Morris, 2001a).

Epipalaeolithic sites were mostly small, open-air camps used by mobile groups of hunter-gatherers with some rockshelter and cave sites (Goring-Morris, 2001a). Early Epipalaeolithic sites were smaller, more ephemeral and more rare than those dating from the Middle Palaeolithic and Late Epipalaeolithic (Herskovitz *et al.*, 1995;Nadel and Werker, 1999). The Late Epipalaeolithic marked a major change in settlement patterns with much larger and more sedentary base camps, often associated with large cemeteries (Belfer-Cohen, 1991).

Environment

The Epipalaeolithic marked a period of dramatic climate change, from the Last Glacial Maximum (LGM) to a significantly warmer climate by the end of the period. The peak of the last ice age is dated to around 20,000 years BP and soon after this time the

climate began to warm and the great ice sheets began to retreat around 17,000 BP (Goring-Morris, 2001a).

The Epipalaeolithic hunter-gatherers exploited a wide range of plant and animal species, including nuts, seeds, fruits lentils and tubers, as well as gazelle (*Gazella* sp.), fallow deer (*Dama mesopotamica*), wild boar (*Sus scrofa*), aurochs (*Bos primigenius*) and ibex (*Capra* sp.) (Goring-Morris, 2001a). Evidence for the exploitation of fish was also found during the Early Epipalaeolithic (Nadel and Hershkovitz, 1991).

Tool industries

While there was much regional variability in Epipalaeolithic tool assemblages, they mainly comprised of blades, bladelets, points, scrapers, burins and microliths (Goring-Morris, 2001a;Nadel, 1990). The basis of subsistence in the Epipalaeolithic was hunting with bow and arrow, meaning that arrowheads were also a prominent feature of the tool assemblages (Rozoy, 1989). Bone tools, ochre and shell bead ornaments were also found in some of the Epipalaeolithic assemblages, being most abundant in the Levantine Aurignacian and Natufian cultural traditions (Rabinovich and Nadel, 1995). Grinding and pounding stones also increase in number and diversity throughout the Epipalaeolithic period (Goring-Morris, 2001a;Nadel and Hershkovitz, 1991).

Hominin remains

Early Epipalaeolithic and Western Asian Upper Palaeolithic hominin remains were scarce when compared to the much earlier Middle Palaeolithic as well as the later Natufian period. This is thought to be due to the ephemeral nature of Early Epipalaeolithic settlements, as well as poor preservation of the skeletons, due to the traditional burial practice of placing the skeletons in shallow pits (Bar-Yosef & Belfer-Cohen 1988; Bilead 1991 in Hershkovitz *et al.* 1995). One of the best preserved hominin skeletons has been found at the site of Ohalo II. This adult hominin skeleton was found lying on its back in shallow pit, with a possible grave good of an incised bone fragment found by its head (Hershkovitz *et al.*, 1995)

The Natufian

During the Late Epipalaeolithic, around 12,000 BP a period of significant warming occurred in Western Asia and during this time, and as a possible result of these

changes, the Natufian tradition developed within the Levant and its surrounding areas (Belfer-Cohen, 1991). This was a more sedentary and complex society than Upper Palaeolithic and Early Epipalaeolithic predecessors. The movement towards a more sedentary lifestyle in the Natufian brought about many changes in settlement patterns, including more substantial habitation structures, storage facilities and cemeteries (Bar-Yosef and Goren, 1973; Belfer-Cohen, 1988; Perrot and Ladiray, 1988; Valla *et al.*, 2004; Weinstein-Evron, 1998).

The faunal and floral evidence suggests that the Natufians were hunter-gatherers who practised specialised hunting, as well as relying heavily on plant exploitation (Bar-Oz *et al.*, 2004; Bouchud, 1987; Saxon, 1974). The remains of gazelle (*Gazella* sp.) dominated the non-human faunal assemblages, but other species included fallow deer (*Dama mesopotamica*), sheep/goat (*Capra* sp.), equids (*Equus* sp.), wild boar (*Sus scrofa*), bovids (*Bos* sp.), waterfowl and fish (Belfer-Cohen, 1991; Goring-Morris, 2001b). The evidence for the intensive exploitation of plant resources comes indirectly from the large number of sickle-blades and grinding tools found within the Natufian tool assemblages. The remains of domestic dogs (*Canis familiaris*) have also been found at some Natufian sites, such as Mallaha and Kebara, and represent some of earliest evidence for dog domestication (Tchernov and Valla, 1997).

Natufian stone tool assemblages were characterised by the dominance of lunate-shaped microliths, scrapers, burins, triangles, arrowheads and borers, and the use of bifacial, Helwan retouch and microburin techniques (Belfer-Cohen, 1991; Garrod and Bate, 1937; Goring-Morris, 2001b). In addition, new tool types emerged, including sickle blades, picks and axes (Bar-Yosef and Goren, 1973). The groundstone tool assemblage became more sophisticated during the Natufian, with mortars and pestles, mullers, plates, shaft straighteners, stone bowls and whetstones (Belfer-Cohen, 1991). The Natufian tool industry also included a rich bone assemblage, including points, spatulas, needles, harpoons and sickle-hafts (Garrod and Bate, 1937; Perrot, 1966; Stordeur, 1994).

Art objects, figurines and personal ornamentation were present in large numbers during the Natufian and the most common elements were marine shell beads and perforated tooth pendants (Bar-Yosef and Belfer-Cohen, 1999; Belfer-Cohen, 1991; Garrod and Bate, 1937; Neuville, 1951). At the site of Hayonim 520 dentalium shells were recovered within two graves (Belfer-Cohen, 1991). The presence of exotic materials at some of the sites, although rare, indicates evidence of long distance trade (Belfer-

Cohen, 1991). Obsidian found at the Natufian site of Mallaha in Israel, for example, appears to have originated in Anatolia (Belfer-Cohen, 1991).

One of the most prominent features of the Natufian is the appearance of large burial grounds, and over 400 skeletons have been discovered from 12 Natufian sites (Belfer-Cohen and Hovers, 1992). These burials represent a mixture of primary and secondary interments; some are individually buried and others in groups; and some with jewellery and grave goods and others without (Belfer-Cohen, 1995). Studies of these hominin remains have shown that dental attrition was severe and they possessed more dental caries and periodontal disease than is typical in hunter-gatherers, resembling that of subsistence farmers (Smith, 1973; Smith, 1972; Smith, 1991b). Smith (1991b) suggests this indicates that the Natufian were eating a more abrasive and cariogenic diet than their Middle and Upper Palaeolithic predecessors.

4.5 Mesolithic

At the end of the Pleistocene later Upper Palaeolithic groups in central and northern Europe developed new technologies in response to the rapidly changing environmental conditions. These Mesolithic hunter-gatherer communities date to between 11,000-6,000 BP according to area (Dickson, 2001). One of the richest data-bases for the Mesolithic period is from north-west Europe and particularly from Southern Scandinavia, where the Mesolithic period has been divided into three main phases: The Maglemosian, c.9500-7000 BP, Kongemose c. 7600-6,500 BP and Ertebølle 6,500-5,000 BP (Dickson, 2001).

Mesolithic settlements were mostly located along watercourses or on the shores of inland lakes and the sea (Escalon de Fonton, 1956; Hansen *et al.*, 1972; Péquart *et al.*, 1937; Roche, 1965; Schilling, 1997). A common feature of these sites were the shell or 'kitchen' middens, composed of mollusc shells, charcoal, flint waste, large stones, layers of ash, hearths, fish bones and in some instances human remains (Péquart and Péquart, 1929; Roche, 1965; Tilley, 1996).

Environment

By around 10,000 BP the Pleistocene glaciers in Scandinavia and the Alps had retreated more or less to their current locations (Bogucki, 2004a). As the ice sheets of the LGM receded, humans began to colonise further northwards in Europe into

southern Scandinavia and the climate reached modern day temperatures by about 9,000 BP (Simmons, 2004). This establishment of a mild, moderate climate allowed forests to develop and adaptations to this new environment inhabited by Mesolithic Modern Humans lead to many technological, social and symbolic innovations (Dickson, 2001).

The reindeer herds which had contributed so much to the Upper Palaeolithic diet retreated after the LGM to northern Scandinavia (Roberts, 1989). They were replaced in Europe by woodland species, such as elk (*Alces alces*), aurochs (*Bos primigenius*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*) (Bröste *et al.*, 1956; Darnedru and Onoratini, 2003; Lacam *et al.*, 1944). While there is evidence for broad spectrum hunting and gathering since the Middle Palaeolithic (Stiner *et al.*, 1999), it became more common during the Mesolithic with these modern humans exploiting a range of species, such as fish, crabs, turtles, molluscs, land snails, waterfowl, rabbits and other small game, with an increasing reliance on plants, such as fruits, tubers, nuts and seeds (Dickson, 2001; Escalon de Fonton, 1956; Péquart *et al.*, 1937; Roche, 1965). Indeed, there appears to have been a much larger emphasis on fishing and fowling supported by an high number of bird and fish bones as well as evidence of fishing equipment, such as fish hooks, basket traps and nets (Darnedru and Onoratini, 2003; Tilley, 1996). The disarticulated remains of domestic dog (*Canis familiaris*) have also been discovered amongst occupational debris (Albrethsen and Brinch Petersen, 1976). In addition, fully articulated skeletons of domestic dogs have been found within burials, some associated with humans while others were buried separately (Larsson, 1988).

Tool industries

The Mesolithic was characterised by a distinctive microlithic stone tool industry, which included Upper Palaeolithic type tools, such as backed blades and bladelets and burins, as well as new tools types, including axes, adzes, and chisels (Albrethsen and Brinch Petersen, 1976; Dickson, 2001; Lacam *et al.*, 1944; Péquart *et al.*, 1937). Spears, picks, harpoons, denticulates, borers, mattocks, mortars, querns and other grinding tools were also present (Escalon de Fonton, 1956; Petersen, 1984). These tools were predominantly made from flint and groundstone, but Mesolithic Modern Humans also made extensive use of wood, producing dugout canoes, axe handles, spear shafts, bows, and antler and bone to make awls, bodkins, borers and adzes (Dickson, 2001; Péquart *et al.*, 1937; Roche, 1965). The predominant weapon of the Mesolithic

was the bow and arrow, with arrowheads therefore becoming common during this period (Dickson, 2001). A variety of portable objects have also been found at Mesolithic sites, including stone, bone and antler objects for adornment and decoration, such as beads, pendants, carved depictions of animals, as well as rock art (Albrethsen and Brinch Petersen, 1976; Bröste *et al.*, 1956; Dickson, 2001).

Hominin remains

The Mesolithic period witnessed the development of formal cemeteries in Europe, containing both single and multiple burials (Bennike, 1997). These burials were often elaborate, associated with burial structures, grave goods, red ochre and also included the remains of animals (Goring-Morris, 2001b). At the Mesolithic site of Dragsholm, for example, a double-grave was discovered containing the remains of two women (Bröste *et al.*, 1956). Red ochre, as well as grave goods, including an ornamental bone dagger and pierced teeth pendants, surrounded both skeletons.

Studies of these skeletons have highlighted the extreme degree of wear and attrition in their teeth. At sites such as Skateholm and Vedbaek, this extreme wear and attrition has been attributed to the chewing and grinding of plant foods (Albrethsen and Brinch Petersen, 1976). Frayer's (1978b) in depth study of the dentition in Upper Palaeolithic and Mesolithic populations showed that individuals from the Mesolithic had smaller dentitions than those from the Upper Palaeolithic. This dental reduction was especially apparent in male individuals with a marked decrease in the sexual dimorphism of tooth size during the Mesolithic.

4.6 Neolithic

The transition from hunting and gathering to agriculture was one of the most important developments in human history. This western Asian transition began about 10,000 BP when Modern Humans began to select for desirable characteristics in wheat, barley, sheep and goats and later in cattle, pigs, lentils and peas (Banning, 2001a). Farming spread from western Asia into south-eastern Europe and from there into the rest of Europe between 8,500 and 4,000 BP (Bogucki, 2004b). In some areas colonising farmers dispersed into new habitats and elsewhere local hunter-gatherers adopted crops and livestock (Tilley, 1996). The Neolithic also witnessed the emergence of pottery production, an increase in settlement sizes, densities and permanency,

associated with general population growth and an increase in sedentism (Banning, 2001b).

In western Asia, the Natufian was followed by the Aceramic Neolithic, which has been dated to c.10,500 - 7,500 BP (Banning, 2001a). It marked the beginning of village life with small permanent or seasonal agricultural village settlements, containing substantial round or rectilinear mud-brick architecture, though some cave sites remained in use, and were typically located near to permanent springs or rivers (Galili, 1987; Lechavallier, 1978d; Lechavallier and Ronen, 1994b). The Aceramic Neolithic period has been divided into the Pre-Pottery Neolithic A, B and C, based mostly on technological differences (Banning, 2001a). It was succeeded by the Ceramic Neolithic, dated to between 8000 and 6,100 BP (Banning, 2001b). These settlement sites were mainly small villages, which mostly contained dense accumulations of rectilinear stone or mud-brick houses that were sometimes enclosed within an external wall (Banning, 2001b).

In north-west Europe, the Neolithic directly followed the Mesolithic and has been dated to c.8500-4,000 BP according to area (Prescott, 2001). This transformation from the hunter-gather economy of the Mesolithic to the farming communities of the Neolithic took over 1,000 years to complete. It gave rise to a major widening in exchange systems and massive monuments also began to emerge within the landscape (Tilley, 1996). These structures were mostly wooden mortuary houses covered in earth and made into mounds (Prescott, 2001).

Environment

In both the Aceramic and Ceramic Neolithic in Western Asia Modern Human subsistence was based on agriculture and animal husbandry, supplemented by hunting and gathering (Davis, 1985). Domesticated plants and animals included wheat, barley, peas, lentils, sheep, goats, cattle and dogs (Kislev *et al.*, 2004; Mienis, 1978). Modes of food production varied throughout Europe during the Neolithic from agriculture with a strong pastoral component to more or less pure hunter-gathering and were often combined to form a mixed economy (Tilley, 1996). Plant cultivation focused mainly on wheat and barley and their animal stock were represented mainly by pig, cattle, sheep and goat.

Tool industries

The Neolithic tool assemblages from Western Asia contained a high percentage of blades or bladelets and medium to large symmetrical projectile points (Galili *et al.*, 1989; Lechavallier, 1978e). It also included burins, scrapers, borers, points and axes, as well as bone tools, mostly points, needles and spatulas (Galili *et al.*, 1989; Lechavallier, 1978c; Lechavallier *et al.*, 1994). The main technological development which separated the Aceramic and Ceramic Neolithic was the production of pottery. The types of pottery produced during the Ceramic Neolithic were diverse with a dark burnished surface or geometric painted or incised decoration (Banning, 2001b). Ornamental objects, such as engraved bones, grooved and perforated stone, jewellery and engraved animals have also been found at Neolithic sites in Western Asia (Galili *et al.*, 1989).

The European Neolithic tool kit contained polished and flaked flint, core axes, adzes, chisels, flake axes, shaft-hole axes, transverse points, blade points and bifacial points (Prescott, 2001). Bone and antler was used for bodice pins, needles, beads, slotted points, harpoons, projectile points, chopping tools, buttons and awls. Amber, teeth and shell were used for personal ornaments, mainly beads (Prescott, 2001). Pottery has also been found at some European Neolithic sites. These pottery vessels varied greatly in size and style, both within and between regions, and included stamped, impressed, painted and incised decorations (Whittle, 1996). Clay, bone and stone figurines have also been discovered at some sites, including both human and animal forms (Whittle, 1996).

Hominin remains

Most Neolithic sites from Western Asia contained single burials with the skeletons buried in a flexed position and often beneath house floors (Arensburg *et al.*, 1978; Galili, 1987; Le Mort, 1994). In some cases skulls were subsequently removed and buried separately. In certain cases plaster was applied to the skulls to model the human face (Arensburg *et al.*, 1978; Banning, 2001a). Funerary structures were more common in Neolithic Europe, especially in Scandinavia, and included long barrows, dolmens, passage graves, stone-packing graves, small mounds and cists graves (Bröste *et al.*, 1956; Prescott, 2001). Others continued to be buried, as in the Mesolithic, in flat earth graves.

There has been a general trend of dental reduction since the end of Pleistocene and this continued throughout the Neolithic period. A change in tooth wear patterns was also noted by Smith (1984), who identified a change in occlusal molar wear from the flat angle of hunter-gatherers to more oblique angle in early Neolithic groups. This change was attributed to a reduction in food toughness or fibrousness, associated with dietary change and the more intensive use of grinding stones and pottery in food preparation amongst these groups. Dietary changes that took place during the Neolithic have also been attributed to an increase in the incidence of dental caries, dental attrition and tooth loss (Molleson and Jones, 1991).

4.7 The Inuit of Alaska, Canada and Greenland

The Inuit of Alaska, Canada and Greenland are scattered along the coasts and islands of arctic America from Greenland to the western most Aleutian islands and east coast of Siberia. Traditionally, they live in permanent settlements whose location is determined by their hunting and fishing grounds. In summer they migrate short distances inland when they live in skin tents, hunt caribou, musk-oxen, game birds and fish; during winter they venture out onto the sea ice near islands or the coast where they build snow houses and subsist almost exclusively on seal and other marine mammals (Leigh, 1925). Recent contact with industrialised populations has witnessed a rapid decline in the Inuit's traditional lifestyle (Davies and Pedersen, 1955; Mayhall, 1970).

Subsistence and material culture

Very little edible vegetable life is available on the arctic tundra, and beyond a few berries and roots; no vegetable matter is eaten (Leigh, 1925). The traditional diet is based almost exclusively on proteins and fats, which comes from seal (*Phoca vitulina*), walrus (*Odobenus rosmarus*), sea lion (*Eumetopias jubatus*), beluga (*Delphinapterus leucas*), caribou (*Rangifer tarandus*), bear (*Ursus* sp.), whales, birds and fish (Waugh, 1937). This meat is often frozen or dried and stored and eaten raw.

The traditional Inuit tool kit is limited being mainly comprised of harpoons, knives, hammerstones and un-worked fragments of stone (Waugh, 1937). The most diverse and commonly used of the Inuit tools is the 'ulos', a knife. This is often used by Inuit women to skin animals.

Skeleton

The Inuit of Alaska, Canada and Greenland are morphologically distinct from other groups of Modern Humans, with stocky body proportions built for strength and endurance, and broad faces with exceptionally high, long and narrow heads with enormously developed muscles of mastication (Hylander, 1972;Hylander, 1977;Leigh, 1925). Their dental arches are well developed and broad. Their alveolar processes are also well developed and shovel-shaped incisors are a common feature of their dentition (Bang and Hasund, 1971;Pedersen, 1947). The masticatory musculature of traditional Inuit is very strongly developed and capable of exerting an unusually large masticatory force (Davies and Pedersen, 1955;Pedersen, 1947). Women's masticatory musculature is more developed than men's (Leigh, 1925). They have often been noted for their heavy tooth wear by early explorers, anthropologists and visitors (Bang and Hasund, 1971;Davies and Pedersen, 1955;de Poncins, 1941;Mayhall, 1977;Moorrees, 1957;Pedersen, 1947;Waugh, 1937). The general level of attrition is high with mature adult's teeth often worn down to the gums (Pedersen, 1947). Multiple chips and fractures are common in adult Inuit dentitions (Turner and Cadien, 1969).

Their meat and fat diet is not as abrasive as many vegetable food stuffs, although it may require strenuous and prolonged chewing (Davies and Pedersen, 1955;Pedersen, 1947). This suggests their heavy tooth wear and strong masticatory muscles are engaged in other activities. Teeth are still used as a tool for many kinds of work, including: the preparation of seal hides which are traditionally still thoroughly chewed; animal sinew is pulled across the teeth and rolled against the cheek to make them apt for sewing; detangling dog sled traces; retrieval of hunted seals from the water during the cold weather, tool handling, pulling lines tight, sewing, as a vice and opening oil drums (Davies and Pedersen, 1955;Leigh, 1925;Mayhall, 1970;Mayhall, 1972;Mayhall, 1977;Pedersen, 1947;Waugh, 1937). Furthermore, when performing heavy physical activities, such as kayak paddling the Inuit males are often observed clenching their teeth very firmly (Davies and Pedersen, 1955;Pedersen, 1947). These functions naturally dispose the dentition to trauma and heavy wear.

4.8 Summary

Fossil evidence for anatomically Modern Humans can be found in Africa from about 200,000 BP (McDougall *et al.*, 2005). From here they spread into Western Asian c. 100,000 BP, but it was not until c. 40,000 BP that they began to spread into parts of

Europe. This movement into Europe was associated with tool technologies now collectively called Upper Palaeolithic industries. The Modern Human tool kit continued to develop, allowing them to live in different habitats, exploiting a new and more diverse range of resources. The Neolithic period witnessed a major change in the hunter-gatherer way of life towards one of a more sedentary agriculturalists or pastoralists. Over this time the Modern Human skeleton has also changed, with a general pattern of reduced robusticity. Modern hunter-gatherer populations provide us with a useful model for understanding the behaviour of these ancient hunter-gatherers through their archaeological and fossil remains. However, Modern hunter-gatherers, such as the Inuit of Alaska, Canada and Greenland, inhabit more marginal environments than most of these ancient hunter-gatherers.

Chapter 5 – Research Questions

The background provided by the three preceding Chapters (2, 3 & 4) on tooth wear, Neanderthals and Modern Humans allows us to extend and outline the four main research questions.

Question 1

Neanderthals possessed a unique facial and dental morphology that has traditionally been explained by heavy dental loading on the anterior teeth and jaw. Most observers support this argument by pointing to heavy wear of Neanderthals' anterior teeth, but is this wear exceptional when compared with that of other late Pleistocene hominins?

The 'Anterior Dental Loading Hypothesis' maintains that the unique Neanderthal facial anatomy was an adaptive response to a high magnitude of forces, resulting from both the masticatory and cultural use of the anterior teeth (Brace, 1995; Demes, 1987; Rak, 1986; Smith, 1983). Neanderthal anterior teeth are also relatively large when compared with their cheek teeth and their incisors possessed enlarged lingual tubercles with the addition of pronounced shovelling and strong labial curvature in the upper incisors (Bailey, 2006; Ungar *et al.*, 1997). These features have also been linked to masticatory stress as well as the heavy wear described in Neanderthal anterior teeth (Clement, 2000; Puech, 1981; Trinkaus, 1983b; Wallace, 1975). A review of the literature would therefore predict that the Neanderthal tooth wear pattern would be dominated by particularly heavy anterior tooth wear, heavier than that seen in Late Pleistocene Modern Humans, or indeed later Modern Humans, none of whom possess the Neanderthal facial morphology.

Hypotheses:

- Neanderthals possess heavy anterior tooth wear, relative to Late Pleistocene Early Modern Humans.
- This heavy anterior tooth wear pattern was unique to Neanderthals.

Question 2

The stocky body proportions of recent Inuit are often used as supporting evidence for the idea that Neanderthals were cold-adapted. The robust jaws and exceptionally heavy tooth wear of Inuit hunter-gatherers have also been seen as comparable to those of Neanderthals. Is recent Inuit tooth wear a good model for understanding Neanderthal tooth wear?

The Neanderthals have frequently been compared to the cold-adapted Inuit of Alaska, Canada and Greenland. The presence of heavy wear on both Inuit and Neanderthal anterior teeth has led to the idea that they might have been used for similar tasks. While relatively little is known about the cultural use of the teeth in the Neanderthals, much more is known from the ethnographic literature about the Inuit (see Chapter 4.7). Inuit and Neanderthal tooth wear has, however, never been formally compared. The published literature predicts similar tooth wear patterns.

Hypothesis:

- Neanderthals and recent Inuit possess similar wear patterns in their anterior teeth.

Question 3

Neanderthals and Early Modern Humans from Western Asia possessed similar Middle Palaeolithic tool kits. With a similar type of technology, it might be expected that the pattern of tooth wear would be similar in each group. Is this so, and how does this change during the Upper Palaeolithic?

If it can be supposed that the dentition formed an integral part of the hominin tool kit then it would follow that groups of hominins who possess similar tool kits should also exhibit similar tooth wear patterns. Both Early Modern Humans and all but the very youngest Neanderthals have been found in association with standardised Middle Palaeolithic tool kits. In addition, non-human faunal analysis has shown that they were hunting similar sized animals and similar species. This makes these two groups of hominins highly suitable for testing the relationship between the hominin tool kit and the dentition.

In contrast the earliest Modern Humans from Europe possessed different tool kits to both the Neanderthals and Early Modern Humans from Western Asia. They were

associated with more specialised Upper Palaeolithic tool industries, such as the Aurignacian, Solutrean, Gravettian, and Magdalenian, which included tools made from bone, antler and ivory, as well as objects of personal ornamentation and art.

Hypotheses:

- Neanderthals and Middle Palaeolithic Modern Humans possess similar tooth wear patterns.
- Both Neanderthals and Middle Palaeolithic Modern Humans possess a different wear pattern to the Upper Palaeolithic Modern Humans of Europe.

Question 4

Are Middle Palaeolithic, Upper Palaeolithic and Early Epipalaeolithic Modern Human tooth wear patterns exceptional when compared with the later Modern Humans associated with different tool kits?

The end of the Pleistocene was a period of major environmental change and the Late Epipalaeolithic and Mesolithic cultural periods witnessed considerable developments in tool technology and in lifestyle. Modern Human groups were hunting a broader range of animals, including large numbers of fish, shell and birds, and were intensifying their use of plant foods. In certain areas they were also becoming increasingly sedentary. These changes culminated in the Neolithic with the development of agriculture and the first permanent villages. We would therefore expect Middle, Upper Palaeolithic and Early Epipalaeolithic Modern Humans to possess different wear patterns to the groups from these later cultural periods.

Hypotheses:

- Neolithic Modern Humans possess different wear patterns to Middle and Upper Palaeolithic Modern Humans.
- Epipalaeolithic and Mesolithic Modern Humans possess tooth wear patterns that are transitional between Middle and Upper Palaeolithic Modern Humans and Neolithic Modern Humans.

Chapter 6 - A New Method for Measuring Tooth Wear

From the start, it was agreed that micro-wear (Chapter 2) was not appropriate for the study described here. The intention was to maximise the number of dentitions in the study group and, to do this, it was necessary to use low-resolution cast collections, photographs and published images as well as observations on original fossils. It would never have been possible to visit all the original material. In addition, micro-wear concentrates on the study of the enamel surface, usually on relatively little worn cusps. Most of the individuals in the intended study group had very heavy wear, with most of the enamel lost, and would not have been appropriate for a standard micro-wear study. Indeed, the whole point was to concentrate on the very heavy wear of Neanderthals. For these reasons, it was decided to study dental attrition at a macroscopic level – “macro-wear”. Chapter 2 describes a large variety of methods for recording dental attrition. The most commonly used is a simple ordinal score such as that of Smith, based on the changing pattern of exposure of underlying dentine. Initial trials, however, suggested that it was difficult to score this consistently and that the 8 point score was just too coarse to describe all the variation seen. In particular, very little detail is provided in the later stages of wear when much of the enamel has been lost. In addition, the project focussed particularly on the anterior teeth and it is difficult to make completely clear distinctions between different point score stages for these. A continuously variable measurement was required instead. One possibility was to measure the height of the crown and monitor attrition by the decreasing values. This is problematic for a number of reasons, not least because the starting (unworn) height of the crown varies between individuals. Once again, the whole point was to compare Neanderthal and Modern Human tooth wear, and one of the features that separates the Neanderthals is their large, robust anterior teeth. In addition, it was not possible to measure height in any consistent way from published photographs. It was therefore felt that this method was inappropriate. The final possibility was to base the assessment on dentine exposure as above but, instead of scoring the pattern, to measure the area of dentine exposed in the attrition facet and to express it as a proportion of the total area of the facet. This provides a continuously varying measurement which turned out to show finely detailed differences in variation, is independent of tooth size and can be measured on casts, photographs and originals. Measurements can be taken using a simple image analysis program, on digital photographs, or scans of published images.

6.1 The method

Firstly digital photographs were taken of the occlusal surface of the mandibular and maxillary teeth, using a casio z40 camera and tripod. An example of this is shown below (Fig. 6.1.1). In the case of published photographs, these were scanned in at 300dpi, and casts were photographed in the same way as original specimens.

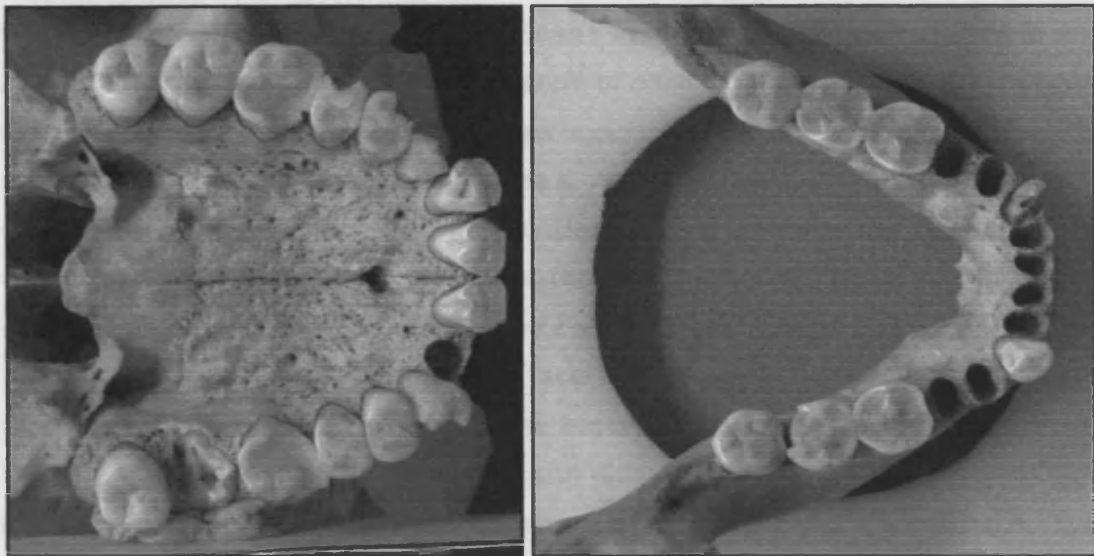


Figure 6.1.1: Digital photographs of the occlusal surfaces of the maxillary and mandibular dentition.

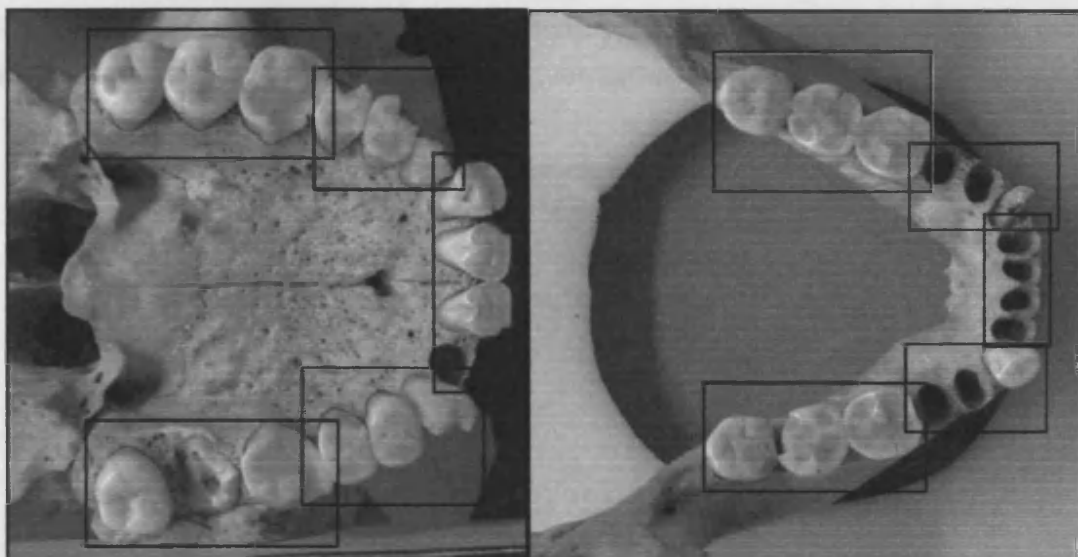


Figure 6.1.2: Digital photographs of the occlusal surfaces of the maxillary and mandibular dentition. The rectangles denote the sections that are isolated for measurement.

Each photograph or scanned image of the mandible or maxilla was divided into five sections for measurement (Fig. 6.1.2). These five sections comprised the left molars; the left premolars and canine; the left and right incisors; the right premolars and canine; and the right molars. These sections were then isolated from the main photograph and enlarged to the size of 20cm along their longest edge. Measurements were then taken from the teeth within each section.

The amount of tooth wear was measured from the photograph or scanned image using the computer software program, Sigma Scan Pro. A graphics tablet was used to draw around the margin of the occlusal wear facet of each tooth. The program determined the area by counting the number of pixels enclosed within the perimeter. The darker area of dentine, often stained brown in the archaeological context, was then measured using the same method (Fig. 6.1.3). If isolated patches of dentine were present on the occlusal surface of a tooth they were measured individually and then added together to calculate the total area. To calculate the dentine proportion the area of dentine was divided by the area of the occlusal wear facet. Pixels were used instead of calibrated measurements to calculate the area of the occlusal wear facet and dentine, because it dispensed with the need for a scale in each picture. Calibrated measurements were not needed because it was the ratio of areas that were being recorded. If the occlusal surface of a tooth had been damaged through heavy chipping, cracking or dental disease a note was made of its presence and it was not measured.

The area of the occlusal wear facets and dentine were output from Sigma Scan Pro into an Excel spreadsheet where the dentine proportions were calculated and these were then copied into an SPSS data sheet for further analysis.

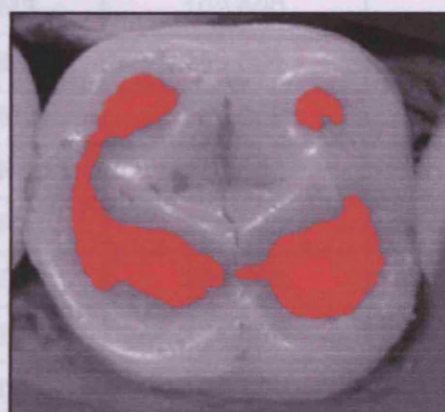


Figure 6.1.3: The area of dentine on the occlusal surface of a lower first molar.

Left and right

It is common in tooth wear studies to measure only the left or the right side of the dentition (Lukacs and Pastor, 1988; Miles, 1962; Molnar *et al.*, 1983a; Richards and Brown, 1981b; Smith, 1984), because wear is often symmetrical. Many specimens included in the current study, did not possess a complete dentition, so it was necessary to substitute an antimere for any missing tooth. In order to test the possible effects of wear asymmetry, a test was carried out on 30 specimens from the main database for this project.

Dentine proportions were compared between the left and right sides of the mandible and maxilla using a Mann-Whitney test. A non-parametric test was used because the wear ratios were not normally distributed. The results of this test are illustrated in the table 6.1.1.

	Mann-Whitney U	Sig. (2-tailed)
Upper M3	51.000	.533
Upper M2	189.500	.776
Upper M1	332.000	.913
Upper P4	267.500	.672
Upper P3	130.000	.311
Upper C	272.000	.741
Upper I2	97.000	.963
Upper I1	46.000	.762
Lower M3	102.000	.663
Lower M2	269.000	.882
Lower M1	368.000	.866
Lower P4	288.500	.818
Lower P3	206.000	.715
Lower C	221.000	.339
Lower I2	139.500	.476
Lower I1	186.000	.704

Table 6.1.1: Results of a Mann-Whitney test of significant differences between the dentine proportions of teeth from the right and left sides of the mandibles and maxillae of a sample group of 30 specimens.

These results show that there were no significant differences between the dentine proportions from the left and right sides of the maxilla and mandible, at the usually accepted 5% level of significance (in fact the values are all much higher than this). It was therefore decided that dentine proportions for the left and right teeth within the maxilla and mandible could reliably be combined. Where both the left and right teeth were present the average of the two scores was taken. Where only a left or right tooth was present, the dentine proportion was recorded for that tooth alone.

6.2 Method testing

The repeatability of this method was tested by calculating both the intra and inter-observer measurement variation for 10 specimens, selected at random, from a collection of medieval skeletons from two monastic sites in London. Furthermore, as the angle of the camera in relation to the occlusal surface of the teeth was not known for all photographs, the effect of camera tilt upon the dentine proportion was also measured. The database of images for this study includes digital photographs of original specimens and casts, as well as scans of published photographs. The measurement variation of the three image sources was calculated.

The measurement variation was calculated using the following equation:

Where, a = the first measurement
 b = the second measurement
 c = the mean of the measurements

$$\text{Measurement variation} = \frac{(a - c) + (b - c)}{2} \times 100$$

Intra- and inter-observer variation

The dentine proportions were measured using the method, outlined above, in ten medieval skeletons. These measurements were re-taken two weeks later and the intra-observer measurement variation calculated. Another observer, TK, measured the dentine proportions in the same ten medieval skeletons and the inter-observer measurement variation was also calculated. Detailed notes were provided on how to measure dentine proportions using the new method and equipment provided. TK had no previous experience of the computer program or measuring teeth using a quantitative method.

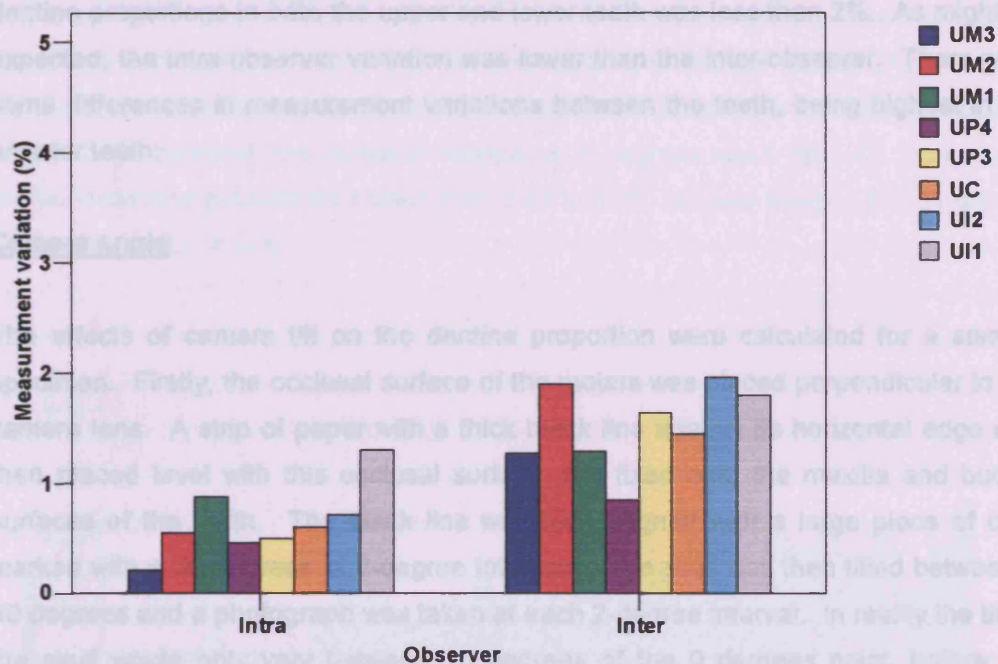


Figure 6.2.1: Intra- and inter-observer measurement variation within the upper dentition of a group of ten medieval individuals from two monastic sites in London.

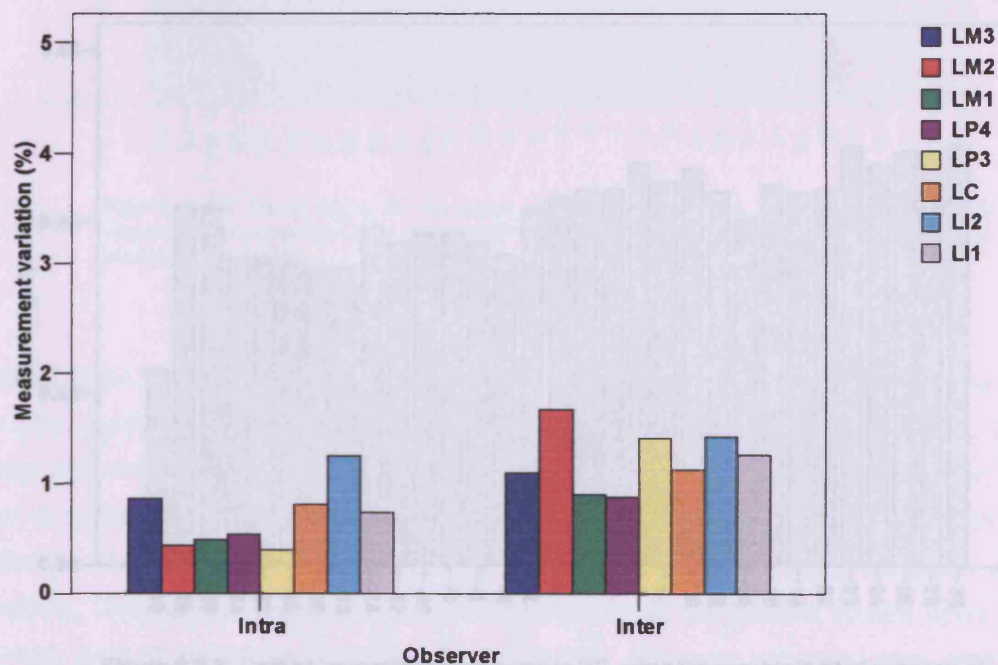


Figure 6.2.2: Intra- and inter-observer measurement variation within the lower dentition of a group of ten medieval individuals from two monastic sites in London.

The results show that both the intra and inter-observer measurement variation for the dentine proportions in both the upper and lower teeth was less than 2%. As might be expected, the intra-observer variation was lower than the inter-observer. There were some differences in measurement variations between the teeth, being highest in the anterior teeth.

Camera angle

The effects of camera tilt on the dentine proportion were calculated for a sample specimen. Firstly, the occlusal surface of the molars was placed perpendicular to the camera lens. A strip of paper with a thick black line against its horizontal edge was then placed level with this occlusal surface and fixed onto the maxilla and buccal surfaces of the teeth. The black line was then aligned with a large piece of card marked with ± 30 degrees at 2-degree intervals. The skull was then tilted between ± 30 degrees and a photograph was taken at each 2-degree interval. In reality the tilt of the skull would only vary between 10 degrees of the 0 degrees point, before the occlusal pictures would become completely impractical.

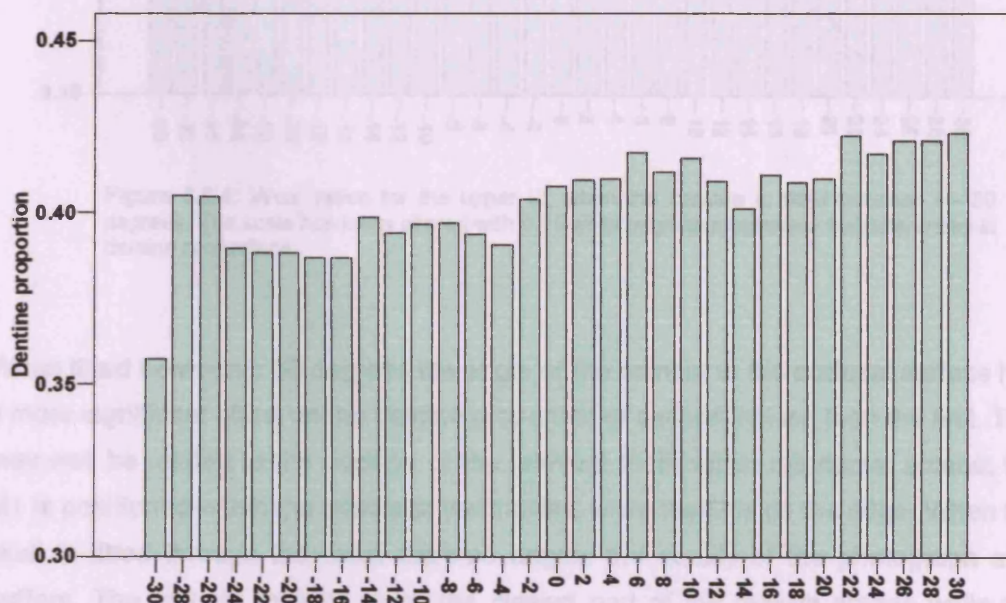


Figure 6.2.3: Dentine proportions for the upper M2, when the camera is tilted between ± 30 degrees. The scale has been altered with 0.30 at its origin to emphasise the differences in dentine proportions.

The dentine proportions were calculated for the upper second molar and second incisor from each photograph. The results show that the camera angle did have an effect on the dentine proportion in both the second molar and second incisor (Figs. 6.2.1 & 6.2.2). For the second molar the dentine proportions ranges varied from 0.36 to 0.42 (Fig. 6.2.3). However, the variation between ± 10 degrees was 0.39-0.42. The second incisor's dentine proportions varied from 0.23 to 0.32, but only from 0.28-0.31 within ± 10 degrees (Fig. 6.2.3).

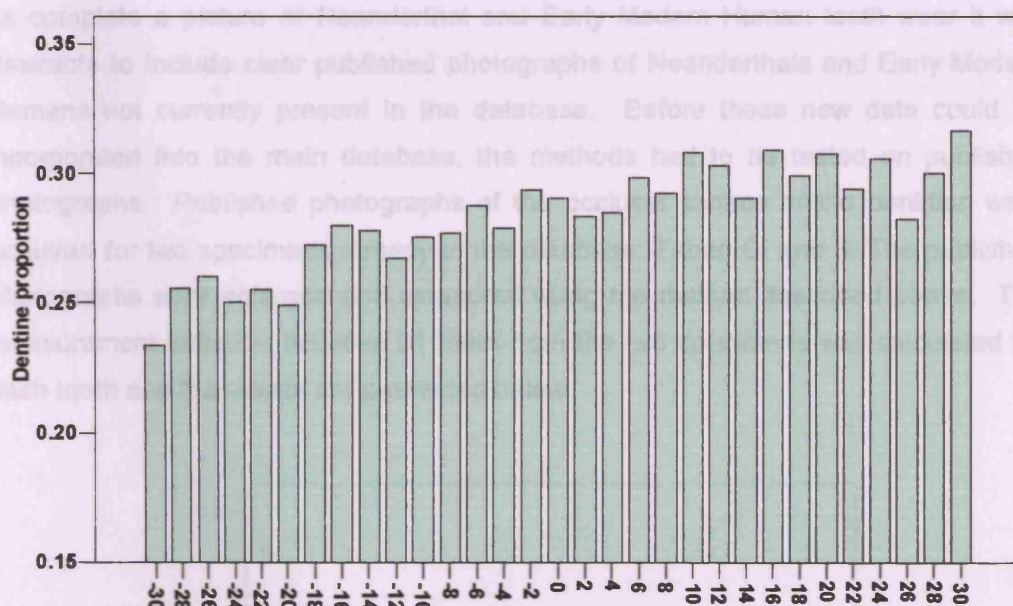


Figure 6.2.4: Wear ratios for the upper I2, when the camera is tilted between ± 30 degrees. The scale has been altered with 0.15 at its origin to emphasise the differences in dentine proportions.

When tilted between ± 30 degrees the angle of the camera to the occlusal surface has a more significant effect on the dentine proportion of second incisor, than the first. This may well be related to the position of the relevant teeth within the dental arcade; the M1 is positioned within the middle of the maxilla, while the I2 is on the edge. When the skull is tilted through the more extreme angles the quality of the photograph also suffers. The camera focuses in on the closest part of the maxilla arcade while the areas, such as where the I2 is located, blur slightly. However, within the more realistic ± 10 degrees there was no difference between the second molar and second incisor. Both teeth show the same general pattern; the dentine proportion rose in value as the

angle between the camera and occlusal surface of the teeth increased, and fell as the angle decreased.

Casts and published photographs

Published Photographs

The compilation of a photographic database of hominin specimens for this project was often limited by several factors; access to the relevant material, a wide geographic spread of the material, and some of the material has been destroyed or lost. To create as complete a picture of Neanderthal and Early Modern Human tooth wear it was desirable to include clear published photographs of Neanderthals and Early Modern Humans not currently present in the database. Before these new data could be incorporated into the main database, the methods had to be tested on published photographs. Published photographs of the occlusal surface of the dentition were acquired for two specimens already in the database: Tabun CI and II. The published photographs were enlarged and measured using the method described above. The measurement variation between 31 teeth from the two specimens was calculated for each tooth and the results are presented below.

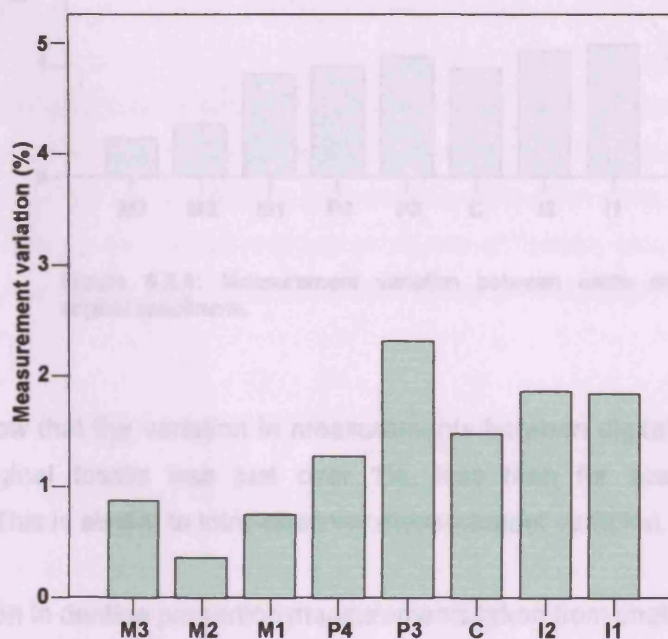


Figure 6.2.5: Measurement variation between published photographs and original specimens.

The results show that the measurement variation between both the scanned images of published photographs and digital photographs of the original fossil were similar to the inter-observer variation in measurement and less than 2% for all teeth.

Casts

Casts of skulls and mandibles are often more readily available than the specimens themselves and provide the researcher with a valuable resource. Again, casts were obtained for three specimens already within the database: La Quina, Spy I and II, and the measurement variation was calculated for 35 teeth.

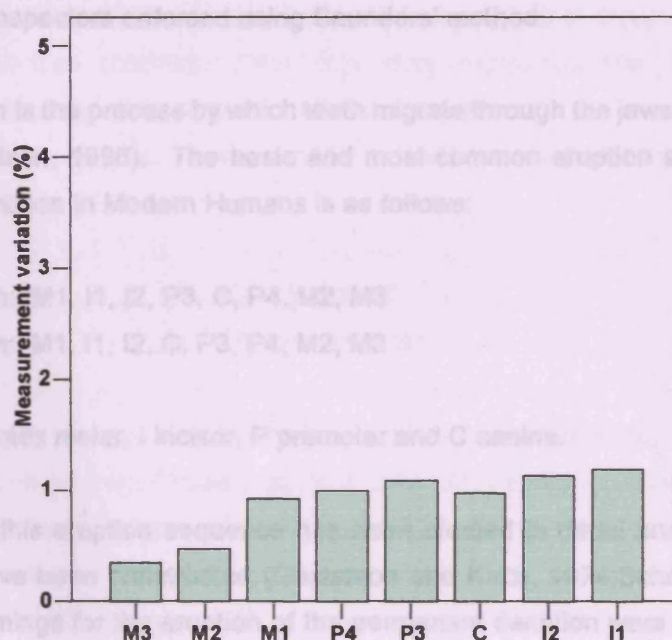


Figure 6.2.6: Measurement variation between casts and original specimens.

The results show that the variation in measurements between digital photographs of casts and original fossils was just over 1%, less than for scanned published photographs. This is similar to intra-observer measurement variation.

The low variation in dentine proportion measurements taken from photographs of casts or scanned published photos, rather than using the original fossil, makes it valid to include these images in the main database.

6.3 Tooth wear patterns and the dental eruption sequence

Dental development, and more specifically, dental eruption sequences have been widely studied in modern humans (Dahlberg and Menegaz-Bock, 1958; Gustafson and Koch, 1974; Hurme, 1949; Hurme and van Wagenen, 1961; Jaswal, 1983; Schour and Massler, 1941; Smith and Gam, 1987). This interest has been fuelled by their importance in aging children and young adults from both archaeological and forensic contexts. The original study by Saunders (1837) was used as an indicator of children's age and motivated by the widespread exploitation of young children in factories following the Industrial Revolution in Britain. It led to the application of age limits which factory inspectors enforced using Saunders' method.

Dental eruption is the process by which teeth migrate through the jaws and emerge into the mouth (Hillson, 1996). The basic and most common eruption sequence for the permanent dentition in Modern Humans is as follows:

Upper dentition: M1, I1, I2, P3, C, P4, M2, M3

Lower dentition: M1, I1, I2, C, P3, P4, M2, M3

Where, M denotes molar, I incisor, P premolar and C canine.

The timing of this eruption sequence has been studied in detail and average timing sequences have been constructed (Gustafson and Koch, 1974; Schour and Massler, 1941). The timings for the eruption of the permanent dentition were calculated using an average of those recorded for a group of male and female, black and white in a study by Gam *et al.* (1972) and are presented in below (Table 6.3.1).

	I1	I2	C	P3	P4	M1	M2	M3
Upper	7	8.1	10.8	10.3	10.9	6.3	12.1	23.2
Lower	6.1	7.1	10.1	10.4	11.2	6.1	11.2	22

Table 6.3.1: Average timing of eruptions for the upper and lower dentition, given in years.

In both these sequences the development and eruption timing of each tooth is calculated separately. More recent studies, however, such as that by Smith and Gam (1987), have highlighted the variability in the eruption sequence and consequently a more general time sequence has been constructed. This new eruption timing sequence divides the permanent dentition into three main phases (Hillson, 1996):

Phase I: Emergence of M1, I1 and I2 (5-8 years).

Phase II: Emergence of C, P3, P4 and M2 (9.5-12.5 years).

Phase III: Emergence of the M3 (late teens to early twenties).

Smith & Gam (1987) studied the tooth eruption sequences of a group of 6,000 black and white American children. From this, they suggested that some individuals departed from the standard sequence with a change in the order of eruption. Their revised sequence is given below and the brackets indicate where the order is commonly reversed:

Upper dentition: M1, I1, I2, [P1, C, P2], M2, M3

Lower dentition: [M1, I1], I2, [C, P1], [P2, M2], M3

They found that teeth from eruption Phase I (first molar and incisors) rarely reversed in sequence with those from Phase II (canine, premolars and second molar). However, reversals in sequence were common in teeth within Phases I and II. Within Phase I only a single variation occurred as a high level: the first molar and first incisor in the mandible were often reversed. This variant occurred in almost 50% of individuals within the American sample. In the maxilla, however, the first molar was much more often the first tooth to erupt. Phase II displays a far more complex variation with the premolars tending to maintain their order in both the maxilla and mandible, but other variants appearing at high levels (20%-40%). Lower teeth usually emerge earlier than their equivalents in the upper jaw, especially the anterior teeth. Female teeth normally erupt earlier than in males and this is seen in most populations (Smith and Gam, 1987). This is as expected because, for most events in their developmental schedule, girls are in advance of boys.

Tooth wear, eruption and age

The dental eruption sequence is an important consideration when interpreting tooth wear patterns because, it dictates the amount of time each tooth is exposed to wear.

The first molar, for example, is normally the first permanent tooth to erupt, between 6-8 years of age, whereas the third molar erupts significantly later in an individual's life, during late teens and early twenties. This difference in eruption timings means that the first molar is exposed to considerably more wear than the third molar - between 10 and 16 years more wear. If we assume a constant rate of wear for all teeth then at any age it follows that the teeth which erupted first will exhibit more advanced wear than those that followed. For example, the first molars should show substantially higher amounts of wear than the second molars as these teeth erupt approximately six years apart. First incisors, which erupt at more or less the same time as the first molars, should show similar wear. If the rate of tooth wear is not constant for all teeth, then the degree of wear will not reflect the expected eruption sequence. This is the fundamental principle of the interpretations of wear patterns that follow in Chapters 8 & 9.

Tooth wear is usually recorded as an overall extent of wear (Buikstra *et al.*, 1994;Hinton, 1982;Kieser *et al.*, 1985;Lovejoy, 1985;Smith, 1984). This information might be useful in estimating the age of individuals, but does little to provide valuable information about wear patterns. This is because tooth wear is highly correlated with age - the older an individual the higher the amount of wear. Age, therefore, often obscures wear patterns and needs to be removed as a factor. To make comparisons of wear patterns between individuals of different age, it is important to remove the effects of the cumulative tooth wear.

A pilot study was made to investigate the difference between wear amounts and the possibility of viewing tooth wear in relation to the expected eruption sequence. A sample of thirty individuals was selected from two medieval monastic sites from London: the Royal Mint and Merton Priory, based on the completeness of their dentitions and the presence of wear. While the sample was strongly dominated by adult males, several adult females were also included. Wear was measured using the method outlined above and calculated as a ratio of the area of dentine to the area of the occlusal wear facet for each tooth. Figures 6.3.1 and 6.3.2 show a simple presentation of the wear ratios for the whole group, with all ages included together, presented as box and whisker plots for each tooth. This is created using the standard plotting function available in SPSS.

Each box plot represents an individual tooth, starting with the back of the mouth (third molars) following through to the front (first incisors). The ends of each box represent

the upper and lower quartile values, and so the height of the box represents the inter-quartile range. The line inside the box represents the median, and the 'whiskers' represent the overall range of values. Outliers are represented by 'O' and 'X' symbols and indicate values which are separated from the upper or lower quartile by more than 1.5 times the length of the inter-quartile range.

All of the teeth show large overall ranges in their wear ratios, presumably due to the mixture of ages at death. The wear patterns are obscured by the variety of ages present. It is, therefore, important to remove age as a factor, but the age at death is unknown. The solution is to present the wear measure of each tooth as a ratio of the wear measure for one particular reference tooth in the dentition. The first molar was selected as it is usually the first tooth to erupt, but any tooth could be used. The dentine proportions of each tooth were divided by the dentine proportion of the first molar from the same jaw. Those teeth with a similar wear state to the first molar should therefore have a wear ratio near 1. Those with more wear should have a wear ratio greater than 1 and those with less wear should have a wear ratio of less than 1.

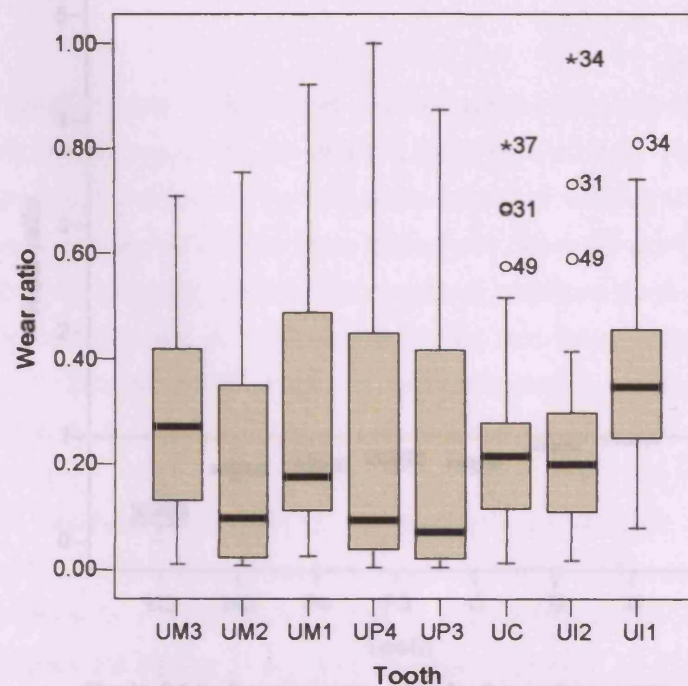


Figure 6.3.1: Wear ratios for the upper dentition of a medieval monastic population from London.

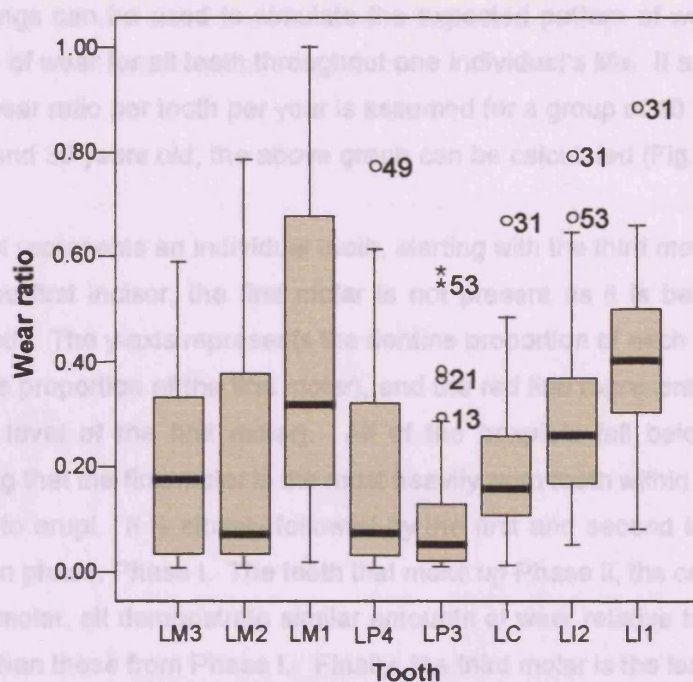


Figure 6.3.2: Wear ratios for the lower dentition of a medieval monastic population from London.

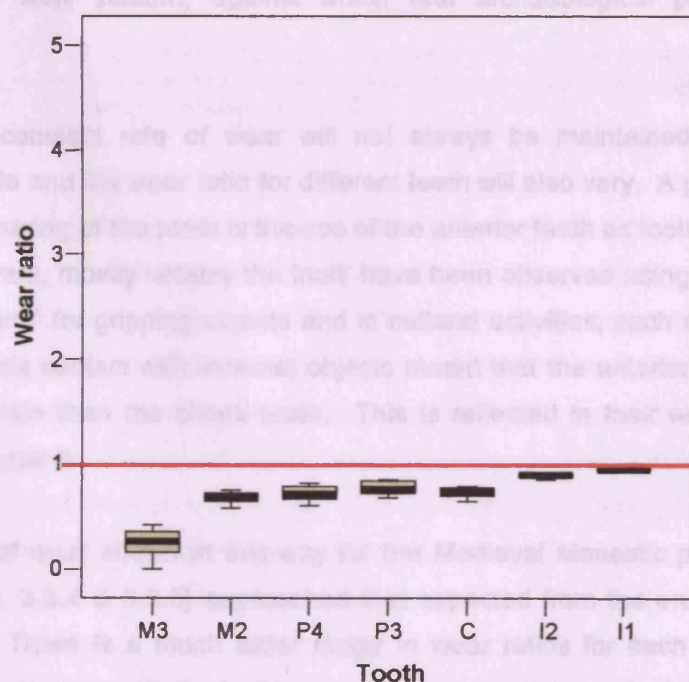


Figure 6.3.3: Expected wear ratios for the dentition, relative to the first molar, based on the expected eruption sequence. (scale 0-1).

Eruption timings can be used to simulate the expected pattern of wear, assuming a constant rate of wear for all teeth throughout one individual's life. If a wear rate of 1% increase in wear ratio per tooth per year is assumed for a group of 10 individuals aged between 20 and 30 years old, the above graph can be calculated (Fig. 6.3.3).

Each box plot represents an individual tooth, starting with the third molar and following through to the first incisor, the first molar is not present as it is being used as the reference tooth. The y-axis represents the dentine proportion of each tooth, (as a ratio of the dentine proportion of the first molar), and the red line represents a wear ratio of 1:1 (i.e. the level of the first molar). All of the boxplots fall below this red line, demonstrating that the first molar is the most heavily worn tooth within the dentition, as it is the first to erupt. It is closely followed by the first and second incisors from the same eruption phase, Phase I. The teeth that make up Phase II, the canine, premolars and second molar, all demonstrate similar amounts of wear relative to the first molar, slightly less than those from Phase I. Finally, the third molar is the least heavily worn, reflecting its late eruption. While some variation in the eruption timings has been discussed, such as the occasional eruption of the first incisor before the first molar, its effect on the expected pattern would be relatively small. This simulated graph provides an expected wear pattern, against which real archaeological patterns can be compared.

In reality a constant rate of wear will not always be maintained throughout an individual's life and the wear ratio for different teeth will also vary. A good example of differential wearing of the teeth is the use of the anterior teeth as tools. Many modern hunter-gatherers, mostly notably the Inuit, have been observed using their front teeth as a 'third hand' for gripping objects and in cultural activities, such as softening raw seal hide. This contact with external objects meant that the anterior teeth wore at a much faster rate than the cheek teeth. This is reflected in their wear patterns, as shown in Chapter 8.

The pattern of wear shown in this way for the Medieval Monastic populations from London (Figs. 3.3.4 & 3.3.5) approached that expected from the eruption sequence (Fig. 3.3.3). There is a much wider range in wear ratios for each tooth, but their median wear ratios are similar to the expected wear pattern. All of the teeth, except the upper first incisor, have median wear ratios either on or below the first molar line (Figs 3.3.4 & 3.3.5). This is consistent with the expectation that the first molar would be the first tooth to erupt. The wear median for the upper first incisor is only slightly

higher than that for the first molar and the inter-quartile range overlaps with it (Fig. 3.3.4), which is not unexpected, as they possess a similar eruption time.

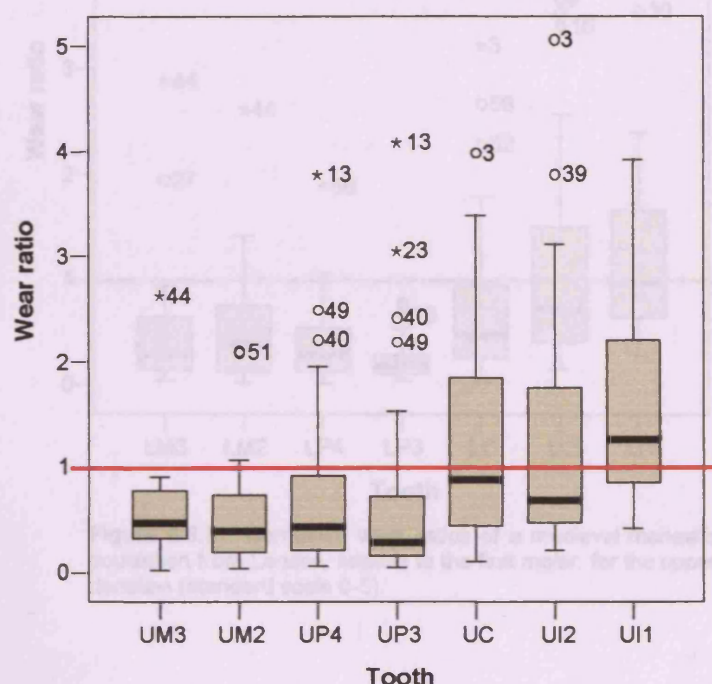


Figure 6.4.4: Combined wear ratios of a medieval monastic population from London, relative to the first molar, for the upper dentition (standard scale 0-5).

The late positioning of the third molars in the eruption sequence is not reflected in the graphs for the upper or lower dentitions. They exhibit similar amounts of wear, relative to the first molar, as the teeth from Phase II of the eruption sequence (Figs. 3.3.4 & 3.3.5). This suggests that the third molars were subject to a particularly high rate of wear compared to other teeth within the dentition. It was observed that many individuals were wearing their third molars heavily on their buccal and occlusal surfaces. This type of wear is indicative of an abrasive object being placed towards the back of the mouth being habitually chewed.

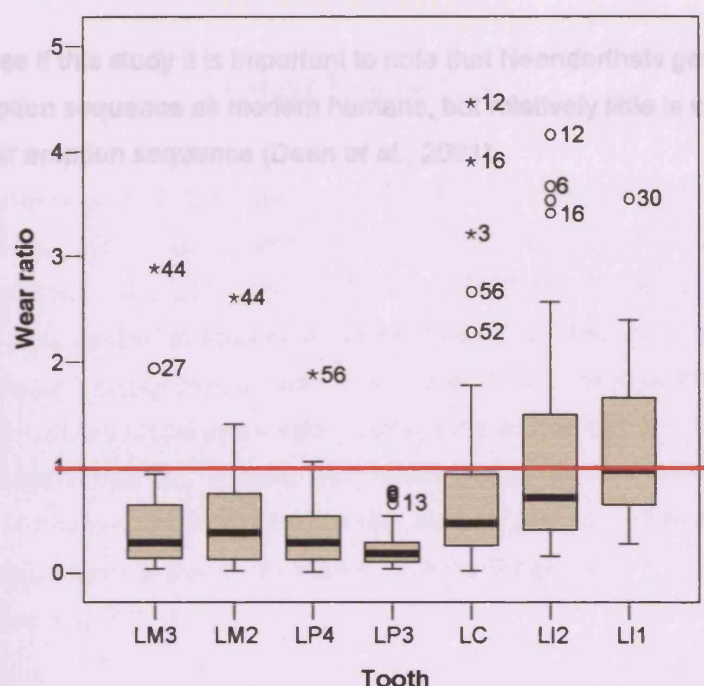


Figure 6.3.5: Combined wear ratios of a medieval monastic population from London, relative to the first molar, for the upper dentition (standard scale 0-5).

Most of the teeth possess between one and five outliers (Figs. 3.3.4 & 3.3.5). These appear to represent individual teeth or pairs of teeth within the dentitions of individuals, rather than the whole dentition of one individual. The lower canines and second incisors of specimen 12, for example, are extremely heavily worn compared to the first molar, but all of the other teeth within the dentition fit within the normal range of the group (fig 5). All of the outliers fall at the high end of the range and none below it. This is also seen in the results presented in Chapter 8.

6.4 Summary

The new quantitative method, described here, provides an accurate technique for recording dentine proportion in large groups of specimens. It can be applied by different observers to all good quality images, whether of original fossils, good quality casts or published photographs. This pilot study of dentine proportions in a small sample of skeletons, from a Medieval Monastic population from London, has demonstrated the importance of viewing tooth wear in relation to the eruption sequence. Removing age as major factor, by viewing amounts of wear relative to the M1, allows clearer and more interesting patterns of tooth wear to emerge.

For the purpose of this study it is important to note that Neanderthals generally possess the same eruption sequence as modern humans, but relatively little is known about the timings of their eruption sequence (Dean *et al.*, 2001).

Chapter 7 - Materials

The dental remains of 301 specimens and 4547 teeth were included in this study. These individuals were divided into the following groups; Neanderthals, Middle Palaeolithic Modern Humans, Upper Palaeolithic/Early Epipalaeolithic Modern Humans, Late Epipalaeolithic Modern Humans, Mesolithic Modern Humans, Neolithic Modern Humans and finally modern day Inuit (Table 7.0.1). Most of these individuals came from sites within Europe and western Asia, but also included two sites from North Africa (Afalou-bou-Rhumel, Algeria and Wadi Halfa, Sudan) and one from the Northwestern Territories, Canada (modern day Inuit of Igloodik). They also spanned a large chronological time period from Marine Isotope Stage (MIS) 7 (c. 200,000 years BP) until present (Fig. 7.0.1).

Dr Charles Fitzgerald and Professor Simon Hillson took most of the images of the archaeological specimens for a research project funded by the Arts and Humanities Research Council on tooth size. All other images were taken by the author or come from published pictures.

Group	Nos. of Specimens	Nos of teeth measured		
		<i>Upper</i>	<i>Lower</i>	<i>Total</i>
Neanderthals	23	121	196	317
Middle Palaeolithic MHs	5	53	45	98
Upper Palaeolithic/Early Epipalaeolithic MHs	27	132	159	291
Late Epipalaeolithic MHs	58	357	482	839
Mesolithic MHs	46	286	397	683
Neolithic MHs	48	323	310	633
Inuit of Igloodik	86	764	922	1686
Total	393	2036	2511	4547

Table 7.0.1: Nos. of specimens and teeth included in the study.

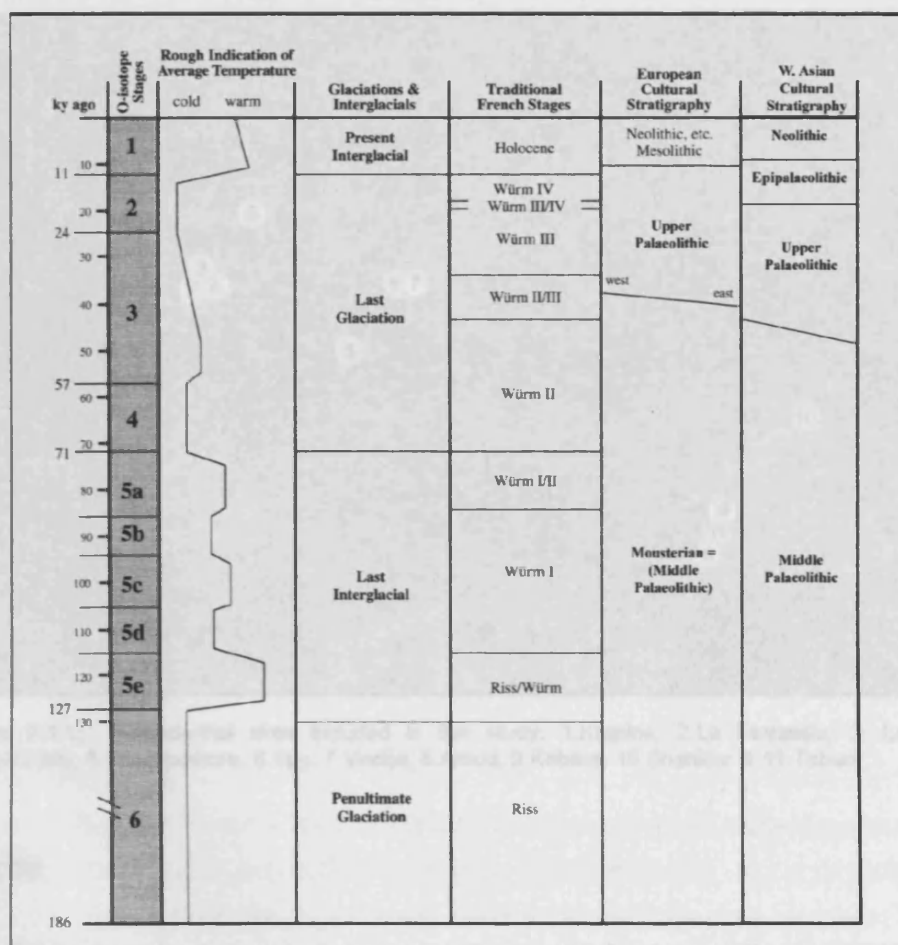


Figure 7.0.1: Climatic and cultural stratigraphy of MIS 6-1, adapted from Klein (1999).

It is therefore important to view the tooth wear patterns presented by these individuals within the context in which they lived. This chapter provides a brief summary of each site including: its location; excavation history; dating; non-human faunal remains; flora; tool industries; and hominin remains. The amount of information published on each site is highly variable, but an extensive literature search was undertaken to gather as much relevant information on each site as possible.

7.1 Neanderthals



Figure 7.1.1: Neanderthal sites included in this study. 1.Krapina, 2.La Ferrassie, 3. La Quina, 4.Régourdou, 5.Saccopastore, 6.Spy, 7.Vindija, 8.Amud, 9.Kebara, 10.Shanidar & 11.Tabun.

Krapina

The Krapina rock shelter is located within the Hušnjakovo hills overlooking the Krapinica River and the town of Krapina, 55km north of Zagreb in Croatia (Fig. 7.1.1). Gorjanovic-Kramberger (1906;1913) excavated the site between 1899 and 1905, discovering one of the largest collections of hominin remains ever recovered from a single site. He identified nine major stratigraphic levels within 11m of Pleistocene deposits, of which levels 3 and 4 yielded the majority of hominin remains (Malez, 1978;Smith, 1976a). These levels also contained concentrations of non-human fauna and stone tools.

Dating

The bulk of the sediments have been dated via the associated non-human faunal remains to the Riss/Würm interglacial and early Würm glacial (MIS 5-4) (Malez, 1970a;Malez, 1978). The hominin remains from Krapina have been dated via U-series and ESR methods to between 178,000 and 120,000 years BP, with mean values of

c. 130,000 years BP (Rink *et al.*, 1995). Collectively, these dates place the deposits and hominin remains within either MIS 6 or beginning of MIS 5e (Table 7.0.1), as indicated by the non-human faunal evidence.

Tool industries

The lithic assemblage from Krapina included over 1,191 artefacts mostly concentrated in levels 3 and 8, both of which contained hominin remains (Simek and Smith, 1997). The assemblage was dominated by scrapers, but notched and denticulated points, as well as naturally backed knives, were also common (Simek and Smith, 1997). Upper Palaeolithic tools were rare. This assemblage was considered to be a 'scraper-rich' variant known as the Charentian Mousterian (Simek, 1990; Simek and Smith, 1997; Svoboda, 2005).

The stone tool industry was based on raw materials that could easily be obtained from the nearby Krapinica River, such as river cobbles (Malez, 1970b; Simek, 1990). The small size of the tool assemblages present in all levels suggested brief periods of occupation at the site. This was supported by the discovery of exotic materials that also indicated a highly mobile lifestyle (Simek, 1990).

Non-human fauna

While the hominin remains from Krapina have received continuous assessment and analysis (Fruyer and Russell, 1987; Kallay, 1963; Radovčić *et al.*, 1988; Smith, 1976a; Wolpoff, 1979) the non-human faunal assemblage has received limited attention. Rhinoceros (*Stephanorhinus kirchbergensis*) remains dominated and cave bear (*Ursus spelaeus*) were also present in all the layers, but only common in the upper layers (Brodar, 1938). Marmot (*Marmota* sp.), wolf (*Canis lupus*), wild cat (*Felis silvestris*), brown bear (*Ursus arctos*), wild horse (*Equus caballus*), wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), bovids (*Bos* sp.), and a selection of birds and reptiles were present in the upper layers, but in much lower numbers than the rhinoceros and cave bear (Brodar, 1938; Gorjanovic-Kramberger, 1906). This is mostly cold and cold-temperate macro-fauna (Malez, 1970c).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The hominin remains from Krapina comprised some 900 specimens, ranging in completeness from partial crania to fragments of individual bones. Most were recovered from levels 3 and 4, but some were found in levels 5, 6, 7 and 8 (Smith, 1976a; Trinkaus, 1978b; Wolpoff, 1979). The number of individuals represented by these remains was estimated at between 75 and 82, including 43 adults and adolescents as well as several juveniles under the age of 14 years (Wolpoff, 1979).

The fragmentary nature of the Krapina hominin remains generated a high level of interest (Bocquet-Appel, 1999; Gorjanovic-Kramberger, 1909; Russell, 1987; Trinkaus, 1985a). No single specimen preserved a complete calotte, upper facial skeleton or longbone (Trinkaus, 1985a). Scratches on many of the hominin bones have been widely interpreted as cut marks (Russell, 1987; Smith, 1976a; Trinkaus, 1985a). Various explanations have been proposed, such as inter-tribal conflict, cannibalism, secondary burial and taphonomy (Gorjanovic-Kramberger, 1906; 1909; Russell, 1987; Tomic-Karovick, 1970; Trinkaus, 1985a; Ullrich, 1978).

The age distribution of the sample, based on the dentition, was unusual for the absence of individuals under 3 years old and over 20 (Wolpoff, 1979). Bocquet-Appel (1999) suggested that this, combined with the concentration of hominins in level 3, represented a catastrophic death assemblage. The preservation pattern at Krapina also suggested rapid burial by kin or, possibly, by rockfall (Trinkaus, 1985a).

All of these remains were thought to come from Neanderthals (Wolpoff, 1979), and six of these individuals were included in the current study.

Krapina 49

This individual was represented by the anterior part of the maxilla and included the incisors, left canine and premolars. The age was estimated to between 15 and 16 years at time of death (Radovčić *et al.*, 1988). A small amount of wear was present on the incisors and canine, and patches of dentine had been exposed.

Krapina 50

This specimen, the anterior part of a maxilla belonging to a young adult, still had the right incisors and canine present *in situ*. This individual had an estimated age of less than 20 years at death (Radovčić *et al.*, 1988). All of the teeth showed evidence for moderate wear with exposed patches of dentine.

Krapina 54

This individual was represented by the left part of a mandible and included the first incisors and the left second incisor, canine, third and fourth premolars and first and second molars. These teeth showed evidence of light wear with patches of dentine only being exposed on the incisors, canine and first molar. The age of Krapina 54 was estimated at between 14 and 16 years old (Radovčić *et al.*, 1988).

Krapina 55

This specimen, the left half of a mandible, still retained the first incisors and the left second incisor, premolars, canine, and first and second molars. It belonged to a young adult estimated to be aged between 14 and 16 years and possessed light wear (Radovčić *et al.*, 1988).

Krapina 58

This relatively well-preserved mandible retained a complete dentition and was thought to belong to a young adult less than 20 years of age (Radovčić *et al.*, 1988). Most of the teeth showed evidence of moderate wear with areas of exposed dentine on their occlusal surfaces.

Krapina 59

This complete mandible of an adult, less than 20 years of age (Radovčić *et al.*, 1988), possessed all of its teeth except for the left third premolar, which appeared to have been lost *ante-mortem*, and the left third molar. These teeth showed evidence of moderate wear with patches of exposed dentine present on all of the surviving teeth.

Most of the teeth discovered at Krapina appeared large in comparison with other Pleistocene hominins (Wolpoff, 1979). In particular, the Krapina anterior teeth were larger on average than for any other Pleistocene hominin. Most of the more complete dentitions (13 of the 18) showed evidence of enamel hypoplasia (Hutchinson *et al.*, 1997; Molnar and Molnar, 1985a; Molnar and Molnar, 1985b; Ogilvie *et al.*, 1989). Few teeth in the assemblage were very worn, although the rate of wear on the anterior teeth was visibly greater than that on the posterior teeth (Molnar and Molnar, 1985a).

La Ferrassie

The site of La Ferrassie is situated at the base of a headland that dominates a small valley in Savignac-de-Miremont, within the Dordogne region of France (Fig. 7.1.1). The site is made up of three main elements: a small rockshelter, a cave and a large rockshelter. The first systematic excavations took place in 1899, under the direction of Capitan and Peyrony, and continued until 1934 (Capitan and Peyrony, 1909; Peyrony, 1934). Heim undertook restoration and conservation works at the site between 1968 and 1973 (Heim, 1974).

While the cave and the small rock shelter both produced interesting finds, it is the large rockshelter that contained the hominin remains as well as the richest archaeological record. The remains of seven individuals were discovered: two adults and five children. Additional remains of a young child were discovered during the conservation works (Heim, 1976). These individuals all came from Middle Palaeolithic deposits, which also contained large amounts of charcoal flakes, blocks of ochre, tool debitage, animal bones and worked flint (Heim, 1976).

Dating

The deposits from the rockshelter were dated stratigraphically to between the Mousterian (Würm II) and the Aurignacian and Perigordian of the Upper Palaeolithic (Würm III) (Delporte, 1984). The hominin remains came from the Mousterian levels (C and D) and were dated using stratigraphical and sedimentological analysis, to c. 40,000 years BP, placing them firmly within MIS 3 (Delporte, 1984; Heim, 1976; Puech, 1981).

Tool industry

The tool assemblage recovered from the large rockshelter was dominated by flaked tools, but also included points, scrapers, discs, worked bone, bifaces and colourants (Heim, 1976; Tuffreau, 1984). Heim (1976) defined the tool industry as Mousterian of La Ferrassie type.

Non-human fauna

The non-human faunal assemblage from the rock-shelter was analysed by Boule and Harlé in 1925, who identified the following species (Heim, 1976): woolly rhinoceros (*Coelodonta antiquitatis*); equids (*Equus* sp.); red deer (*Cervus elaphus*); reindeer (*Rangifer tarandus*) and bovid (*Bos* sp.). The remains of several carnivores were also

identified, including wolf (*Canis lupus*), cave bear (*Ursus spelaeus*), hyaena (*Crocuta crocuta*) and cave lion (*Panthera leo spelaea*). The micro-faunal remains were highly fragmentary, but included the remains of birds, moles and voles (Heim, 1976). This type of assemblage was typically Mousterian in its composition, dominated by the remains of bovid and horse (Heim, 1976). The presence of reindeer and rhinoceros indicated the colder climatic conditions that were present within the region at this time.

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

Heim (1974; 1976) determined that all six skeletons were contemporary, and considered them part of the same small population of Neanderthals. The composition of the collection; an adult male, an adult female and five children, led to the speculation that they represented a family group (Heim, 1974). The excellent preservation of the adult skeletons, combined with their anatomical positioning and articulation, was taken as a strong indication of intentional burial (Delporte, 1984; Heim, 1974).

Both of the adult skeletons were exceptionally well preserved and were included in the current study.

La Ferrassie 1

The remains of an adult male, estimated at 45-years-old, were discovered in the western part of the rockshelter. They included an almost complete skull, mandible and full dentition (Heim, 1974; Heim, 1976).

La Ferrassie 2

The partial skeleton of an adult female of 25-30 years of age was found near La Ferrassie 1 (Heim, 1974). These remains included a fragment of maxilla with the upper right incisors, canine, premolars and first molar *in situ*.

The dentitions of both La Ferrassie 1 and La Ferrassie 2 were exceptionally well preserved, but most of the crowns had been worn away. The upper dentition from La Ferrassie 1 was very heavily worn and is most extreme in the anterior teeth (incisors and canines), where it led to the exposure of some of the pulp cavities. Puech (1981) noted the presence of: more pronounced wear on the left side of the dentition than the right; the heavy rounding of the occlusal edges of the incisors; alveolar recession; and

a possible under-bite (excessive overlap of the upper and lower anterior teeth) when the maxilla and mandible are articulated. Wear was so extreme that a different mode of mastication or diet would have been needed in the later period of this individual's life. Puech (1981) attributed this unusual wear pattern to the forward movement of masticatory pressure caused by a slight under-bite, while Brace (1975) and Wallace (1975) attributed it to the use of the teeth as tools.

La Quina

The site of La Quina is a rockshelter complex that lies at the northern extreme of the Dordogne basin in the Charente region of southwest France (Fig. 7.1.1). It was first discovered in 1872 and excavated between 1905 and 1935 by Dr Henri Martin, and between 1956 and the late 1960s by his daughter Germaine Henri-Martin. These excavations uncovered large quantities of animal bones, an abundant lithic industry and a large collection of hominin remains (Henri-Martin, 1956; Martin, 1909; 1913; 1923a). Unfortunately the material discovered during these excavations was never fully published, which led to renewed excavations at the site in 1985 under the direction of Jelinek and Debénath (Debénath, 1993; Jelinek *et al.*, 1989; Jelinek and Debénath, 1998).

A continuous series of deposits extended for approximately 1000m along the southeastern edge of a small valley. Within them Martin (1909) identified two main concentrations of material, the Station Amont below a high cliff near the centre of the site, and the Station Aval at the southwest end of the site.

Station Amont

This area stretched 100m along the base of the limestone cliff, extended more than 15m from the cliff face, with sediment depths of over 7m (Bierwirth, 1996). It contained a dense concentration of animal bones, Mousterian lithics and the fragmentary remains of over 25 hominins (Hardy, 2004; Henri-Martin, 1956).

Station Aval

This area was located 200m from Station Amont and also contained a series of hearths, lithics and animal bones, but with lower density (Henri-Martin, 1956).

Dating

These Station Amont deposits were divided into upper and lower levels. The upper levels were originally dated by radiocarbon (Henri-Martin, 1964) to 34-35,000 years BP. More recent TL dating of heated flint indicated that an earlier date of 40-48,000 years BP during MIS 3 (Mercier and Valladas, 1998). This was supported by the non-human fauna from the upper levels, which reflect the cold-to-moderate open steppe climate of MIS 3 (Hardy, 2004). The presence of reindeer in the lower deposits led to their association with the late MIS 5 and early MIS 4 (57-71,000 years BP) (Bassinot *et al.*, 1994). The majority of the hominin remains came from these lower levels and were therefore dated to c. 65,000 years BP (Mellars, 1989c).

Tool industries

The tool assemblage from the upper levels at Station Amont was dominated by debitage from the production of stone tools, with formal tools such as denticulates and notches poorly represented (Bierwirth, 1996). The lower levels also contained a limited number of tool types, and this assemblage was primarily comprised of large scrapers, large flakes and a number of quartz cobbles. It has been defined as the type site for the Mousterian industry of La Quina type (Bierwirth, 1996).

There is also evidence within the upper and lower deposits for the use of bone as tools. Numerous small fragments of bone were originally thought to have been fashioned and abraded in a lithic-type reduction sequence (Martin, 1907). It is now believed that stone tools were repeatedly retouched using these small fragments (Chase *et al.*, 1994).

Non-human fauna

The non-human faunal assemblage from Station Amont was dominated by cold climate fauna, such as wild horse (*Equus caballus*), reindeer (*Rangifer tarandus*) and bison (*Bison priscus*) (Armand, 1998; Bierwirth, 1996; Chase *et al.*, 1994). The relative proportions of these types of fauna fluctuated between the upper and lower levels, but the number of other species such as wolf (*Canis lupus*), red fox (*Vulpes vulpes*), hyaena (*Crocuta crocuta*), woolly mammoth (*Mammuthus primigenius*), birds and rodents remained low throughout (Bierwirth, 1996; Martin, 1923b). Human activity was assumed to be primarily responsible for this accumulation, but the effects of taphonomic factors, such as carnivore activity and stream action, made it difficult to determine whether the remains represented a kill or consumption site (Chase *et al.*,

1994). Animal bone also appeared to have been used as a major source of fuel for the hearths (Jelinek *et al.*, 1989).

More detailed faunal analysis highlighted the presence of almost all elements of the skeleton, as well as cut marks on the bones of the larger animals (Hardy, 2004; Martin, 1923b). This strongly suggested that many of these animals were being killed and butchered on-site (Jelinek *et al.*, 1989). All of the deer appeared to have been killed during the warmer months of the year which suggested a seasonal occupation of the site (Guillien and Henri-Martin, 1974).

The heaviest concentrations of animal bone lay directly below the highest cliff escarpment and were dominated by the presence of bison, horse and reindeer. It was suggested that Neanderthals made use of the site to drive game deliberately off the cliff above (Jelinek *et al.*, 1989; Jelinek and Debénath, 1998). An alternative explanation was that the plateau at the base of the cliff was used as a place to trap game (Bierwirth, 1996).

Flora

Stone tool residues suggested that a wide variety of hard silica plant species, such as woods or grasses, were being processed throughout the stratigraphic sequence (Hardy 2004).

Hominin remains

The fragmentary remains of over 25 hominins, identified as Neanderthals, were discovered within the Mousterian levels of Station Amont, but were never described in any detail (Hardy, 2004; Henri-Martin, 1956). Attention has focused on two complete skulls: one belonging to a child of approximately 8-years-old, known as H18; and another from an adult Neanderthal, known as H5. La Quina H5 was included in this study.

La Quina H5

This individual is represented by the almost complete skeleton of an adult, probably female, aged about 25 years (Henri-Martin, 1956). She became known as the 'woman of La Quina' (Hardy, 2004; Henri-Martin, 1956). Her remains included a maxilla and a mandible with an almost complete dentition. Trinkaus (1994) also identified a traumatic lesion on one of her limbs that would have significantly limited its utility. The dentition

only lacks two upper incisors, the lower incisors and right canine. All the teeth were moderately worn, revealing patches of dentine.

Régourdou

Régourdou is a large, collapsed limestone cave located approximately 2km north of Montignac in the Dordogne region of France (Fig. 7.1.1). It was first discovered in 1954 and was the subject of amateur excavations. Fossil hominin remains were discovered in 1957, and Bonifay (1964) undertook systematic excavations between 1961 and 1962. He identified ten stratigraphic levels, of which Beds 2-8 were found to contain Mousterian deposits (Bonifay and Vandermeersch, 1962; Vandermeersch and Trinkaus, 1995). These Mousterian levels contained a complex of stone structures, some of which contained the remains of brown bear (*Ursus arctos*), while others appear to have been constructed in order to escape the cave after periods of rock collapse (Bonifay, 1964). The partial skeleton of an adult hominin was also discovered within one of the Mousterian levels (Bed 4) (Piveteau, 1963).

Dating

Levels 3-8 were associated with non-human fauna indicative of temperate conditions and were dated to the early part of the last Würm I/II of MIS 3, 55-30,000 years BP (Vandermeersch and Trinkaus, 1995). Bonifay (1964) dated Bed 4 to the early part of the last glacial, c.50,000 years BP.

Tool industries

The lithic industry at Régourdou cave was very sparse, suggesting brief periods of human occupation (Bonifay, 1964). The assemblage was identified as Mousterian and contained a few racloirs with flake retouch similar to Quina-type (Piveteau, 1963). Only the lithic assemblage from level 2 was given a typology; a Quina variant of Charentian Mousterian (Vandermeersch and Trinkaus, 1995). The tools from Bed 4, which contained the human remains, were also low in number but included racloirs and denticulates, and an individual racloir buried in association with the hominin skeleton (Bonifay, 1964).

Non-human fauna

The remains of brown bear (*Ursus arctos*) dominated the non-human faunal assemblage from levels 3-8. This assemblage also contained the remains of roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), hare (*Lepus sp.*), beaver (*Castor fiber*),

bovids (*Bos* sp.), rodents and reptiles (Bonifay, 1964). This collection of non-human fauna was associated with a temperate climate, while level 2 was associated with more cold weather species such as reindeer (*Rangifer tarandus*), as well as horse (*Equus caballus*), wolf (*Canis lupus*) and lion (*Panthera leo spelaea*).

Brown bear remains were particularly well preserved. This combined with their positioning within stone structures led to the suggestion that they represented intentional burials by humans (Bonifay and Vandermeersch, 1962). Régourdou thus became known as 'the site of the Bear Cult'. More recently this theory has been met with some criticism. Schwartz and Tattersall (2002a), for example, found no substantive evidence to support it.

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The hominin remains recovered during excavations at the cave belonged to two individuals: Régourdou 1, and Régourdou 2. While Régourdou 2 was only represented by a collection of foot bones, Régourdou 1 was represented by the partial skeleton of a young adult Neanderthal (Piveteau, 1959;1963) and was included in this current study.

Régourdou 1

This partial skeleton included the mandible but lacked the skull, femora, tibiae and fibulae and it has been claimed that brown bear and deer bones were buried in association with it (Piveteau, 1959). The earlier, amateur excavations appeared to have disturbed the surrounding deposits and may even have destroyed some of the bones (Piveteau, 1963). The mandible was very well preserved and contained a full set of 16 teeth (Piveteau, 1963). It was distinctly Neanderthal in morphology, but was intermediate in sexually dimorphic features (Piveteau, 1963).

The teeth were small size in relation to the size of the mandible. All were fully erupted and showed low-to-moderate occlusal wear. This suggests they belonged to a young adult in their mid-20s (Vandermeersch & Trinkaus 1995).

Saccopastore

The site of Saccopastore, a Pleistocene terrace, is situated on a small hill at the base of the valley of L'Aienne, next to the Tiber River in the suburbs of Rome (Fig. 7.1.1). A hominin skull was discovered in 1929 during the quarrying of gravels, and became known as Saccopastore 1. Quarry works were halted and some excavations carried out. During a visit in 1935, Breuil and Blanc discovered a second skull, Saccopastore 2, and systematic excavations were resumed, uncovering both non-human fauna and a lithic industry (Blanc, 1935). The stratigraphic sequence was divided into 6 separate levels; Saccopastore 1 was thought to have come from layer 2a and Saccopastore 2 from layer 3a (Condemi, 1992).

Dating

The long stratigraphic sequence at the site was poorly documented, but comparisons with sites from nearby regions, as well as evidence from soil samples and non-human fauna, have consistently dated the deposits to between 80,000 and 150,000 years BP (MIS 6-5) (Blanc, 1935;1948;1958;Condemi, 1992;Koeppel, 1933;Segre, 1948). The lower layers, which contained the two hominin skulls, were dated to the last interglacial, MIS 5e, from 127 000 to 115 000 years BP (Segre, 1948). This date was supported by the non-human fauna, flora, pollen and lithic industries (Blanc, 1938;Condemi, 1992;Follieri, 1983;Tongiorgi, 1938).

Tool industries

During the 1936 excavations only 11 stone pieces were recovered from the Middle Palaeolithic deposits, all of which were attributed by Blanc (1938;1948) to a Mousterian industry. These pieces were re-examined during a later study by Segre and Piperno, who defined the industry, by the presence of the Levallois technique, scrapers, Mousterian points, Mousterian cores and the preparation of striking platforms, to the Pontian Mousterian (Condemi, 1992).

Non-human fauna

The non-human fauna associated with Saccopastore 1 in layer 2a included: elephant (*Palaeoloxodon antiquus*); rhinoceros (*Stephanorhinus kirchbergensis*); hippopotamus (*Hippopotamus amphibius*); aurochs (*Bos primigenius*), and fallow deer (*Dama dama*) (Condemi, 1992). In layer 3a, associated with Saccopastore 2, elephant (*Palaeoloxodon antiquus*) was absent, but hippopotamus (*Hippopotamus amphibius*), rhinoceros (*Stephanorhinus kirchbergensis*) and aurochs (*Bos primigenius*) were

present. In addition, steppe ass (*Equus hydruntinus*) and red deer (*Cervus elaphus*) were found. The species from both layers indicated a mild, humid climate with a wooded environment (Condemi, 1992).

Flora

Impressions of leaves found within the silts of the terrace deposits highlighted the presence of hazel (*Corylus avellana*), oak (*Quercus*), poplar (*Populus*) and hombeam trees (*Carpinus/ Ostrya*), indicating a cooler climate than is seen in the area today (Tongiorgi, 1938). A more recent study of the fossil pollen retrieved from the site confirmed these results and also revealed the additional presence of zelkova trees (*Zelkova crenata*) (Follieri, 1983).

Hominin remains

Saccopastore 2 was included in the present study.

Saccopastore 2

The partial skull was originally discovered in three pieces and reconstructed by Sergi (1948). It included the base of the skull and a complete face. While it was difficult to sex this skull with any certainty, Sergi (1948) speculated that it was probably male and estimated an age of 20-25 years. This individual, like Saccopastore 1, has consistently been identified as a Neanderthal (Ascenzi *et al.*, 1986; Condemi, 1992; Manzi and Passarello, 1991; Sergi, 1948; Stringer *et al.*, 1984).

All upper teeth were present *in situ*, apart from the incisors and the left third premolar. The teeth were relatively small when compared with those of other Neanderthals, and were within the range of Early Modern Humans (Manzi and Passarello, 1991). The tooth sockets for the incisors were complete and suggested that they were large in size (Schwartz and Tattersall, 2002a). The occlusal surfaces of the remaining teeth were all worn, revealing patches of dentine (Manzi and Passarello, 1991).

Spy

The site of Spy is a cave and terrace located within Berche-aux-Roches, near the modern village of Spy, Belgium (Fig. 7.1.1). The cave was the subject of amateur investigations, but the terrace, which lay directly in front of the cave, remained largely unexplored until Lohest and De Puydt undertook extensive excavations in 1885 and

1886 (Fraipont and Lohest, 1886). These excavations uncovered the remains of two adult hominin skeletons: Spy 1 and Spy 2.

The deposits from the cave and terrace were divided into five separate layers; A-E (Fraipont, 1885). The skeletons were found on the surface of the lowest layer E and probably represented an intrusion from layer D. Layer D contained flint tools that were typical of the Mousterian and non-human fauna (Fraipont, 1885). In addition, the layer above (C) contained worked ivory objects, cut and engraved bone, charcoal and limestone blocks that have been associated with the Aurignacian (Fraipont and Lohest, 1886).

Dating

The early excavation date has caused problems with dating, which relies upon the associated non-human fauna. This correlated the hominins with the early part of the last glacial (MIS 4-3) 35-70,000 years BP (Fraipont, 1885; Fraipont and Lohest, 1886; Oakley, 1964; Zeuner, 1940).

Tool industries

Layer D contained a Mousterian tool industry, including retouched blades and Mousterian points. Few details have been published, but Bordes (1968) determined it was of Mousterian of Quina type. Two Mousterian points, a blade and a bone point, were found in close proximity to the skeletons (Fraipont and Lohest, 1886).

Non-human fauna

The non-human faunal assemblage from layer D was dominated by woolly rhinoceros (*Coelodonta antiquitatis*), wild horse (*Equus caballus*), aurochs (*Bos primigenius*), woolly mammoth (*Mammuthus primigenius*) and hyaena (*Crocota crocuta*) (Fraipont, 1891; Fraipont and Lohest, 1886). Red deer (*Cervus elaphus*), reindeer (*Rangifer tarandus*), cave bear (*Ursus spelaeus*) and badger (*Meles meles*) were also present, but in much lower numbers. This is a cool-climate fauna.

Bocherens *et al.* (2001) undertook isotopic analysis of the Spy hominins, which indicated that most of their dietary protein came from large herbivores, especially those with strongly positive $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, such as reindeer and suckling herbivores, or even omnivorous mammals such as bears (Bocherens *et al.*, 2001).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

Two partial adult skeletons, two teeth and a tibia belonging to a juvenile were discovered at the site. All were identified as Neanderthals (Fraipont and Lohest, 1886) and both adults were included in this study.

Spy 1

The remains of this adult included a partial skull, an almost complete mandible and a fragmented post-cranial skeleton (Fraipont, 1891). It was probably a male aged around 35 years (Schwartz and Tattersall, 2002a). The skeleton was discovered lying on its right side with the head towards east and feet towards west, and one hand placed on the mandible (Fraipont and Lohest, 1886). This mandible included a complete lower dentition, but the upper dentition lacked incisors and left molars.

Spy 2

The remains of this individual were found close to Spy 1, but the excavators were unable to determine its anatomical position (Fraipont, 1891). It included parts of the skull, with a fragmented maxilla, the upper right fourth premolar, first and second molar, and the left third molar, two fragments of the mandible containing all molars and the right premolars, and a fragmented post-cranial skeleton belonging to a male of about 26 years of age (Fraipont, 1891).

Spy 1's teeth all showed evidence of wear exposing patches of dentine. Spy 2's dentition was less heavily worn.

Vindija

Vindija cave and terrace are situated approximately 275m above sea level near Ivanec, 55km north of Zagreb in northwestern Croatia (Fig. 7.1.1). The cave is made up of a single chamber approximately 50m deep, 28m wide and more than 10m in height. Vukovic, in 1928, was the first to excavate the cave, and these excavations continued intermittently over a period of 30 years. Both the cave and terrace were excavated, but these investigations were mostly limited to the Upper Palaeolithic deposits (Vukovic, 1949;1950;1970). Malez and colleagues undertook renewed excavations at the site

between 1974 and 1986, this time focusing on both the Middle and Upper Palaeolithic levels (Malez *et al.*, 1980; Malez and Rukavina, 1979; Malez and Ullrich, 1982).

Over 12m of stratified deposits were discovered, including 8m of Pleistocene deposits (Malez *et al.*, 1980; Wolpoff *et al.*, 1981). These deposits were divided into 13 stratigraphic units (A-M) and contained cultural remains from the Mousterian, Aurignacian, Gravettian, Epi-Gravettian, Neolithic, Bronze Age and Roman periods (Malez and Rukavina, 1979). Excavations uncovered the remains of approximately 60 hominin specimens, associated with Mousterian or Upper Palaeolithic industries, and a further 45 specimens associated with the Epigravettian (Malez and Ullrich, 1982).

Of most interest to this study is level G, a Middle Palaeolithic level associated with hominin remains and a mostly Mousterian tool assemblage. This level was divided into five separate units, G₁-G₅. Attention has been focused on the findings from layer G₁, including the remains of late Neanderthals, which were tentatively associated with Upper Palaeolithic tool industries (Higham *et al.*, 2006; Karavanic and Smith, 1998; Malez *et al.*, 1980; Smith *et al.*, 1999). However, the Neanderthals used in this study came from the underlying level of G₃.

Dating

The hominin remains from level G₁ were originally dated by radiocarbon methods to 29,080 ± 400 years BP and 28,020 ± 360 years BP (Smith *et al.*, 1999). This represented an unexpectedly late date for the presence of Neanderthals in central Europe, but more recently dates were revised to an earlier date of 32,000 years BP (Higham *et al.*, 2006). This also agreed with a radiocarbon date from the cave bear remains, from within the same level, of 33,000 ± 900 years BP (Obelich *et al.*, 1994).

The hominin remains from level G₃ were also radiocarbon dated to c. 42,000 years BP (Krings *et al.*, 2000). This was supported by dates from animal bones from the same layer; 42,000 years BP using the amino acid racemization method and c. 41,000 years BP using the Uranium series method (Wild *et al.*, 2001). These dates appeared to be in sequence with those gained from the overlying layer G₁ and both appear to suggest MIS 3.

Tool industries

The Middle Palaeolithic tool assemblage at Vindija was mostly composed of waste production, such as flakes, cores and stone hammers (Paunovic *et al.*, 2001). The

stone tools from this assemblage were defined as the Mousterian and included the characteristic denticulates and scrapers (Paunovic *et al.*, 2001). In addition, the hominins from layer G₃ were associated with some end-scrapers and possible leaf-point fragments more characteristic of the Upper Palaeolithic (Karavanic & Smith 1998; Ahern *et al.* 2004). It has been suggested that the Neanderthals from layer G₁ were associated with an Upper Palaeolithic tool assemblage (Karavanic and Smith, 1998), but this issue remains contentious (Zilhão and d'Errico, 1999).

Flora

In 1983 samples of all sediments were taken for palynological analysis (Draxler 1986), but only the samples from layers G and F showed evidence of pollen grains and spores.

Non-human fauna

The non-human faunal assemblage from Layer G₃, like those from all of the other Pleistocene layers, was dominated by cave bear (*Ursus spelaeus*) (Paunovic *et al.*, 2001). Other carnivores were relatively infrequent and included wolf (*Canis lupus*) and arctic fox (*Alopex lagopus*) (Malez and Ullrich, 1982; Paunovic, 1988). Woolly rhinoceros (*Coelodonta antiquitatis*), reindeer (*Rangifer tarandus*), elk (*Alces alces*), bison (*Bison priscus*), aurochs (*Bos primigenius*), ibex (*Capra ibex*), roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*), wild boar (*Sus scrofa*) and giant deer (*Megaloceros giganteus*) were also present in the assemblage (Malez and Ullrich, 1982; Paunovic, 1988). In addition to this list of species, level G₃ contained the remains of red deer (*Cervus elaphus*) (Malez and Ullrich, 1982). The non-human fauna also included a range of fish, reptile and bird species, as well a variety of rodents.

In addition to the faunal material, stable isotope evidence derived from two Neanderthal specimens from level G₁ showed high $\delta^{15}\text{N}$ values (Richards *et al.*, 2000). These indicated that the overwhelming majority of the individuals' dietary protein came from animal, rather than plant sources. The associated $\delta^{13}\text{N}$ values indicated the exploitation of more open range herbivores, despite the hilly terrain of the local area (Richards *et al.*, 2000).

Hominin remains

Level G₃ contained the majority of the hominin remains from this site, and they have been firmly identified as Neanderthals, but with putatively similar features to the central European *Homo sapiens* (Ahern *et al.*, 2004; Paunovic *et al.*, 2001; Smith and Ranyard,

1980; Svoboda, 2005). The remains were highly fragmentary and only two of the more complete specimens were included in this study.

Vi 206

This mandibular fragment extended from the middle of the left canine socket to the midpoint of the right ramus. It contained the right canine and molars and its general morphology was similar to that of late Neanderthals from western Europe (Wolpoff *et al.*, 1981).

Vi 231

This mandibular fragment was broken in an almost identical fashion to Vi 206, but comes from the opposite side of the skeleton. It preserved the left third premolar and all of the left molars, as well as the sockets of the missing teeth. It is slightly larger and more robust than Vi 206, but the dental dimensions were almost the same (Wolpoff *et al.*, 1981).

The teeth from both specimens only showed moderate amounts of wear, with only small patches of dentine exposed on the crowns of the teeth.

Amud

Amud cave is situated on the margins of the Dead Sea Rift Valley, 5km to the northwest of the Sea of Galilee and 110 meters below sea level (Fig. 7.1.1). It is located within a steep cliff that overlooks Wadi Amud and consists of a small chamber, a large open middle terrace and a lower terrace.

Excavations took place in 1961-1964 (Suzuki and Takai, 1970) and 1991-1994 (Rak *et al.*, 1994). They revealed over 4.5m of deposits ranging from the Middle Palaeolithic (Unit B) to the Holocene (Unit A) (Rabinovich and Hovers, 2004). Unit B was subdivided into four separate sub-units, labelled 1-4, of which B1, B2 and B4 were rich in stone artefacts and faunal remains (Rabinovich and Hovers, 2004).

Dating

Unit B was originally dated, using the associated lithic assemblage, to the transitional phase between the Upper and Middle Palaeolithic, c. 30,000 years BP (Suzuki and Takai, 1970). More recently, thermoluminescence (TL) dating has placed this unit to between 70,000 and 50,000 BP (MIS 4-3) (Valladas *et al.*, 1999); TL dating placed sub-

units B1 and B2 over a relatively short time span c. 55,000 years BP and this was confirmed by the sedimentological evidence. Sub-unit B4 was TL dated to c. 70,000 years BP. The greater antiquity of the upper Middle Palaeolithic layers was also confirmed by electron-spin resonance (ESR) dates taken from animal teeth, which produced ages of 42,000 years BP and 49,000 years BP, depending upon the uptake model (Grün and Stringer, 1991).

Tool industries

The Middle Palaeolithic layers contained retouched Levallois points, Mousterian points, truncated points, denticulated points, racloirs, borers, backed knives, end-scrapers, burins, scrapers, blades and cores. The high frequency of Upper Palaeolithic tool types led Watanabe (1970) to ascribe the assemblage to a transitional form between the Middle and Upper Palaeolithic. Re-analysis by Akazawa (1979) and Ohnuma (1992) placed it closer to the Tabun B variant of the Levantine Mousterian. This was confirmed through the analysis of new lithics gathered from the more recent excavations at the site (Hovers, 1998).

Non-human fauna

More than 20,000 pieces of fossil mammalian bone were unearthed during the 1960s excavations at Amud (Takai 1970). Of the identifiable material, two species dominated the Middle Palaeolithic levels: gazelle (*Gazella* sp.) and fallow deer (*Dama mesopotamica*) (Rabinovich and Hovers, 2004). The assemblage of medium-to-large game also included: wild goat (*Capra aegagrus*); red deer (*Cervus elaphus*); roe deer (*Capreolus capreolus*); aurochs (*Bos primigenius*); wild boar (*Sus scrofa*); and rhinoceros (*Stephanorhinus hemitoechus*). Small carnivores, such as red fox (*Vulpes vulpes*), occurred in low frequencies, and large carnivores, such as bear (*Ursus* sp.), were rare. The faunal assemblage fitted neatly within the context of the Late Mousterian Levant, including medium-to-large mammals with a dominance of gazelle and fallow deer, a rarity of large-bodied species and the dominance of fully formed individuals. This suggested selective hunting, targeting the largest and prime specimens. Many burned bone fragments were identified in the occupation layers (Rabinovich and Hovers, 2004), accompanied by a large number of hearths, suggesting that bones might have been used as fuel.

Flora

Phytolith analysis of hearth deposits indicated that the woody parts of trees and shrubs were primarily used as fuel for fires, and herbaceous plants for bedding and/or fuel

(Madella *et al.*, 2002). The species composition was consistent with the site's location and indicated that the Amud Neanderthals used local sources of plants.

Hominin remains

The remains of at least 16 individuals, all identified as Neanderthals, were discovered within the Middle Palaeolithic levels at Amud, mostly represented by isolated teeth and fragmentary long bones (Hovers *et al.*, 1995; Lavi, 1994; Lieberman, 1995; Rak *et al.*, 1994). These remains were concentrated in the northwest part of the cave near to the wall, and were dominated by infants and young children (Hovers *et al.*, 1995). The completeness and articulation of three individuals recovered from the Middle Palaeolithic layers (Amud 1, 2 and 7) strongly suggested that they represented intentional burials (Hovers *et al.*, 1995). The most complete adult was Amud 1 and this individual was included in the present study.

Amud 1

This individual was located at the top of Unit B, just below the Middle-Upper Palaeolithic interface (Suzuki and Takai, 1970), recently dated to c. 50,000 years BP (Grün and Stringer, 1991; Valladas *et al.*, 1999). This almost-complete skeleton belonged to an adult male around 25 years old at death (Sakura, 1970). His skeleton was found lying in a horizontal position on his left side with the upper and lower limbs bent. Despite arguments to the contrary (Gargett, 1989; 2000), most researchers agree that this represented an intentional burial (Hovers *et al.*, 2000), but no burial architecture or grave goods were found.

This individual possessed a complete set of 32 upper and lower teeth. Schwartz and Tattersall (2002b) observed that the upper teeth appeared small in relation to the size of the skull. The upper first incisors may have been shovelled, but were too heavily worn to tell, and the upper second incisors were barrel shaped. All teeth were moderately worn with exposed patches of dentine.

Kebara

The site of Kebara is made up of a large cave and terrace on the western face of Mount Carmel in Israel (Fig. 7.1.1). It is located approximately 65m above sea level, overlooking the Mediterranean coastal plain, and is only 13km south of the Middle Palaeolithic sites of Tabun and Skhul. The cave itself is funnel-shaped, with a high-arched entrance and tall chimney at the rear. The terrace is located directly in front of

the cave and appears to have been formed through a large rock collapse c. 30,000 years BP (Bar-Yosef *et al.*, 1996).

Dorothy Garrod was the first to investigate this site, digging test-pits in the cave in 1930. Turville-Petre and Baynes excavated the cave more fully the following year (Turville-Petre, 1932). During these excavations a total area of 300m², with an average depth of 3m, was examined revealing deposits from the Natufian, Kebaran and Upper Palaeolithic. Unfortunately, both Turville-Petre and Baynes died before these excavations were published in detail. Stekelis undertook new excavations at the cave between 1951 and 1965, including further examination of the Upper Palaeolithic levels and the first look at the Middle Palaeolithic layers. During these excavations the remains of an 8-9 month old baby were discovered in the lower Mousterian layers (Smith and Arensburg, 1977). Bar-Yosef and Vandermeersch undertook the most recent excavations at the site between 1982 and 1990 (Bar-Yosef *et al.*, 1992; Bar-Yosef and Vandermeersch, 1991). It was during these excavations that the most significant discovery was made; the almost complete upper body skeleton of an adult Neanderthal.

Kebara cave contained evidence of dense human occupation during the Middle Palaeolithic, with numerous well-preserved hearths and ash deposits (Meignen and Bar-Yosef, 2000). These deposits were divided into two major occupational episodes (Bar-Yosef *et al.*, 1992). The first episode was represented by hearths and ashy deposits, with very few artefacts. The second represented repeated occupations, accumulating 3-3.5m of deposits and included a large concentration of bone refuse (Goldberg and Laville, 1988). The well preserved hearths provided strong evidence for the use of fire (Schiegl *et al.*, 1996).

Dating

Kebara cave possessed occupation levels from the Mousterian to the Natufian and included over 4m of Middle Palaeolithic deposits, TL dated to between 60,000 and 48,000 years BP (Valladas *et al.*, 1987), ESR dates were between 60,000 ± 6,000 and 64,000 ± 4,000 years BP (Schwarcz *et al.*, 1989). Both dating techniques placed the deposits within the end of MIS 4 and beginning of MIS 3 (Table 1). The boundary between the Mousterian and Upper Palaeolithic levels was dated by both radiocarbon and TL to c. 45,000 years BP (Valladas *et al.*, 1987).

Tool industries

The Middle Palaeolithic layers contained an abundant lithic industry that most closely resembled the Tabun Level B and Amud Level B variants of the Levantine Mousterian (Meignen and Bar-Yosef, 2000). This industry was characterised by numerous points and flakes with little retouch, and was dominated by end-scrapers, steep scrapers, and some burins, mostly made from flakes (Bar-Yosef, 1991b). Lithic production appeared to have taken place inside the cave, attested by the proliferation of debris from knapping as well as rich assemblages of usable blanks, cores and some retouched items (Meignen and Bar-Yosef, 2000).

Non-human fauna

The Middle Palaeolithic non-human faunal assemblage was dominated by the bones of medium-to-large mammals, densely concentrated in a relatively narrow zone along the north wall of the cave (Bar-Yosef *et al.*, 1992; Speth and Tchernov, 1998). Small mammals were extremely rare (Lev *et al.*, 2005). Medium-to-large mammals were dominated by gazelle (*Gazella* sp.) and fallow deer (*Dama mesopotamica*) (Speth and Tchernov, 2002). Less frequent species included roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), wild goat (*Capra aegagrus*), wild boar (*Sus scrofa*), equids (*Equus* sp.) and aurochs (*Bos primigenius*). Human involvement in the accumulation of these bones was indicated through the presence of cut marks and burning. These remains suggested that the Kebara Neanderthals were capable hunters, as the mortality profile showed a bias towards fully grown adults in their prime. This pattern was similar to those of Upper Palaeolithic and Holocene hunters, believed to be indicative of an ambush strategy (Stiner, 1994). Additionally, 2,500 fragments of tortoise (*Testudo graeca*) bones and shell were found in the Middle and Early Upper Palaeolithic levels (Speth and Tchernov, 2002). The abundance of these remains suggested that they were also an important food resource for the Kebara Neanderthals.

Flora

The most recent excavations at Kebara Cave produced an exceptionally large carbonised plant assemblage from samples of the Middle Palaeolithic hearth deposits (Bar-Yosef *et al.*, 1992). Phytoliths were thought to have been brought into the cave as wood, bark and plant material used as fuel for the fires (Albert *et al.*, 2000). The floral assemblage included 3,956 identifiable charred seeds and fruits, most of which belonged to the legume family (Lev *et al.*, 2005). While many of these were used as fuel, some of the seeds were ripe or nearly ripe, suggesting that they made a significant contribution to the vegetarian part of the Neanderthal diet (Lev *et al.*, 2005).

Hominin remains

Several isolated fragments of Neanderthal remains were discovered within the Middle Palaeolithic levels at Kebara, but attention has focused on the more complete remains of two skeletons: Kebara 1 and Kebara 2 (Bar-Yosef *et al.*, 1992). Kebara 1, the partial skeleton of a 8-9 month old Neanderthal baby, has been dated to between 50 and 60,000 years BP (Smith and Arensburg, 1977). Kebara 2 was discovered in 1983, low down in the sedimentary deposits, 7.8m below the surface and towards the middle of the cave. This skeleton has been TL dated, via associated burned flints, to c. 60,000 years BP (Valladas *et al.*, 1987). It is this skeleton that was included in the current study.

Kebara 2

The Kebara 2 skeleton was well preserved but unfortunately lacked a cranium. It was discovered lying on its back, with the right hand on the thoracic cavity and the left hand at the level of the lumbar vertebrae (Bar-Yosef *et al.*, 1992). The skeleton is believed to have represented a male with a minimum age of 25 years at death (Karasik *et al.*, 1998; Schwartz and Tattersall, 2002b). It is thought that the burial was intentional (Arensburg *et al.*, 1985).

Kebara 2 retained all 16 of its lower teeth and, in a detailed account of the mandible, Schwartz and Tattersall (2002b) described these teeth as quite well worn with the incisors somewhat concave lingually, but not shovelled. Substantial alveolar resorption, dental calculus, periodontal disease and a high degree of hypercementosis were also observed (Tillier *et al.*, 1995).

Shanidar

Shanidar cave is located within the Zagros Mountains in northeastern Iraq, and is set some 765m above sea level, giving it a commanding view of the Shanidar Valley (Fig. 7.1.1). Solecki first investigated the site in 1951, digging test pits and establishing a basic stratigraphic sequence. He returned in 1953 and continued work until 1960. The large limestone cave contained over 14m of deposits, divided into 4 layers (A-D). They dated from the Middle Palaeolithic (layer D) to the Upper Palaeolithic (layer C) and Neolithic (layers A and B) (Solecki, 1952). Layer D was over 8.5m thick and contained hearths, animal bones, stone tools and the remains of nine Neanderthals (Shanidar 1-9) (Trinkaus, 1983b).

Dating

The top of the Middle Palaeolithic layer D was radiocarbon dated to c. 50,000 years BP (Vogel and Waterbolk, 1963). However, Trinkaus (1983b) noted that this is beyond the reliable radiocarbon dating limit and should be treated as a minimum age only. Solecki (1972) estimated a date for the base of layer D from the deposition rate as c. 100,000 years BP. Charcoal samples associated with Shanidar 1, 3 and 5 were radiocarbon dated to c. 45,000 years BP and towards the end of MIS 3 (Vogel and Waterbolk, 1963). The position of Shanidar 2, 4, 6, 8 and 9 lower down in the stratigraphic sequence suggest an earlier date of c. 60,000 years BP or between MIS 4 and 3 (Trinkaus, 1978a).

Tool industries

Layer D from this site contained a relatively homogenous Mousterian stone tool assemblage, interpreted as a single industry (Akazawa, 1975;Solecki, 1952;1963). It was dominated by Mousterian points and side-scrapers, especially single-edged side-scrapers (Akazawa, 1975;Skinner, 1965).

Non-human fauna

The remains of non-human fauna were discovered throughout layer D, with two main concentrations (Solecki, 1963;Solecki, 1971). They were dominated by wild goat (*Capra aegagrus*), red deer (*Cervus elaphus*), and wild sheep (*Ovis orientalis*). Tortoise (*Testudo graeca*), wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*) and fallow deer (*Dama mesopotamica*) were also present, but in lower numbers (Evins, 1981;Perkins, 1964;Reed and Braidwood, 1960). The primary source of food therefore appeared to have been large game. Carnivore remains were also found throughout the deposit, including wolf (*Canis lupus*), red fox (*Vulpes vulpes*) and brown bear (*Ursus arctos*).

Flora

In general, the preservation of pollen throughout the cave was poor (Leroi-Gourhan, 1975), but a concentration of pollen grains within the Shanidar 4 burial generated great interest (Chase and Dibble, 1987;Gargett, 1989;Solecki, 1971;Solecki, 1975;Sommer, 1999). They included at least eight different species of small and brightly coloured wild flowers (Leroi-Gourhan, 1975), suggesting this individual had been laid to rest on a bed of flowers and woody branches (Solecki, 1971;Solecki, 1975). More recent analysis

has suggested that small rodents, known to store flower heads and seeds, are likely to have been responsible (Chase and Dibble, 1987; Gargett, 1989; Sommer, 1999).

Hominin remains

The skeletal remains from layer D included seven adults and two infants. Shanidar 1, 2, 3, 5 and 7 were identified as isolated burials, while Shanidar 4, 6, 8 and 9 were commingled (Trinkaus, 1983b). This is one of the largest known accumulations of archaic hominins and at least some appear to have been intentionally buried (Schwartz and Tattersall, 2002a; Trinkaus, 1983b). Four of these individuals described in Trinkaus (1983) were included in the current study.

Shanidar 1

This exceptionally well-preserved skeleton of an adult male aged between 30 and 45 years was discovered at the top of layer D. He was found lying on his back, slightly turned onto his right side with his arms placed across his chest and legs fully extended. Most of the skeleton was articulated, apart from the head, which had been separated from the body. Further examination of the skeleton showed that sometime prior to his death, Shanidar 1 had sustained several healed injuries: to his right frontal and left orbit; a massive injury to his right side that, resulting in arthritic degenerations of the right knee, ankle and parts of the foot; atrophy/hypotrophy of the right clavicle, scapula and humerus; and fractures and a possible amputation of the distal humerus. His remains included an almost complete mandible and maxilla, with all upper teeth present *in situ* and only two lower first incisors missing.

Shanidar 2

This skeleton represented an adult female aged between 20 and 30 years and was discovered towards the middle of the cave, within layer D. The skull was heavily crushed but well preserved, and was situated between two limestone blocks. Few postcrania survived. The dentition was almost complete and only lacked the lower first incisors.

Shanidar 3

This crushed skeleton, originally catalogued as unidentified bone, was found in close proximity to Shanidar 1 and included: ribs; vertebrae; parts of the pelvis; leg bones, and four teeth. Only the ribs and vertebrae were found in articulation, but suggested that this individual was lying on its right side between the rocks. The reconstruction of the pelvis strongly suggested that this skeleton belonged to a male aged between 35 and

50 years. One rib possessing a strange cut had been in the process of healing at the time of death (Solecki, 1972). It has been suggested that this represents evidence of inter-personal violence amongst the Neanderthals, resulting from contact with a sharp implement.

Shanidar 5

This individual was found towards the top of layer D, just above Shanidar 3, and between a layer of rocks near to Shanidar 1 (Solecki, 1972). The skeleton included highly fragmented limb bones, ribs, vertebrae and parts of the skull, including 11 *in situ* upper teeth and five isolated lower teeth. The legs were in a semi-flexed position with their anterior surfaces facing down and the upper body appeared to have been bent backwards so that the head was next to the pelvis. The large cranium and long bones both suggested that this individual was a male and, according to the tooth wear, was aged between 35 and 50 years.

In general, the Shanidar Neanderthals possessed relatively large anterior teeth, moderately large molars and some elaborations of the occlusal morphology, such as shovelling of the maxillary incisors. Evidence for taurodontism, the enlargement of the pulp chamber, was found in three of the adults. Dental calculus appears to have been deposited on at least one of the posterior teeth of Shanidar 2, 3 and 5. The tooth roots were exposed in Shanidar 1, 2, 3, and 5, but this was probably related to continuous eruption associated with heavy tooth wear rather than periodontal disease. However, the upper left second incisor, third and fourth premolars were missing *ante-mortem* in Shanidar 5, with the alveolar process remodelled to a smooth surface.

All of the Shanidar Neanderthals possessed extensive occlusal wear and moderate approximal wear, removing many morphological features of the teeth (Trinkaus, 1978a). The heavy wear on the anterior teeth had worn away most of the crowns and the posterior tooth crowns were reduced to a ring of enamel surrounding exposed dentine.

Tabun

Tabun cave, also known as et-Tabun (the Oven), is located on Mount Carmel about 20km south of Haifa, Israel (Fig. 7.1.1). It lies approximately 63m above sea-level and 31m above the level of the plain at the opening of Wadi el-Mughara. The cave is roughly divided into an outer chamber, an inner chamber with a chimney, and an

intermediate chamber linking the two. Dorothy Garrod excavated the site between 1929 and 1934 (Garrod and Bate, 1937). Renewed excavations were undertaken by Jelinek between 1967 and 1972 (Jelinek *et al.*, 1973), and more recently by Ronen from 1975 until present (Ronen, 1991).

These excavations uncovered a stratigraphic sequence over 25 meters thick, containing rich collections of lithics, non-human fauna and hominin remains. As a result, Tabun has become a reference site for dating other archaeological deposits in the Levant. Garrod and Bate (1937) used cultural differences within this deposit to divide it into seven layers, A-G, dating from the Bronze Age to the end of the Lower Palaeolithic (Tayacian).

Fossil hominins were discovered in Layers B and C. Small hearths were present within layer B in the outer chamber, but were absent elsewhere in the cave (Garrod and Bate, 1937). Jelinek *et al.* (1973) suggested that these represented the use of the cave as a specialised butchering station during this time, rather than as a domestic camp, with the chimney in the inner chamber acting as a natural game trap. However, recent evidence showed that the fires were associated with brief periods of domestic occupation as well as with animal butchery (Albert *et al.*, 1999).

Layer C contained a mixture of hearths, tools and debitage, as well as a diverse array of fauna. It has been suggested that these represented the use of the cave as a domestic camp (Garrod and Bate, 1937). This theory was supported by the findings of Albert *et al.* (1999), who discovered that the major ash component in this layer was derived from burning wood, and that the cementum of gazelle teeth indicated winter hunting and a seasonal occupation of the site.

Dating

The hominin-bearing layers B and C were originally dated using sedimentology, faunal and lithic assemblages to between 40 and 60,000 years BP (Farrand, 1979;Jelinek, 1982b;Tchernov, 1981). During the 1990s these deposits were subjected to a variety of new dating methods. Dental enamel was dated using ESR and Uranium-series methods and heated flints were dated using TL (Alpersen *et al.*, 2000;Bar-Yosef and Callander, 1999;Grün and Stringer, 2000;Mercier and Valladas, 2003;Millard and Pike, 1999;Rink *et al.*, 2003;Schwarcz *et al.*, 1998). The ESR method dated Layer B to c. 80,000 years BP (MIS 5), and layer C to c. 125,000 years BP (MIS 6) (Grün *et al.*, 1991). The U-series method placed layers B and C slightly later c. 50,000 and

c.100,000 years BP respectively (McDermott *et al.*, 1993). TL dates from the bottom of layer C were even earlier at $171,000 \pm 17,000$ years BP (Mercier *et al.*, 1995).

Methodological advances in both ESR and TL dating during the very beginning of the 21st century led to the re-assessment of the ages for many of the layers at Tabun, including layers B and C. New ESR dates produced an average age of $122,000 \pm 16,000$ years BP for layer B, using a linear uptake model, placing it within MIS 5e (Grün and Stringer, 2000). Similarly, two new ESR dates from layer C gave a revised age of $152,000 \pm 36,000$ years BP and $141,000 \pm 32,000$ years BP, also using a linear uptake model (Grün and Stringer, 2000). The revised TL dates gave layer C an age range of c. 134-180,000 years BP (MIS 6) (Mercier and Valladas, 2003).

The Tabun C1 hominin had an uncertain provenance. It was excavated from the top of layer C, but Garrod believed that it represented an intrusion from layer B (Bar-Yosef and Callander, 1999; Garrod and Bate, 1937). As a result, this individual was the subject of direct dating. The mandible and femur were originally dated by the U-series method to $34,000 \pm 5,000$ years BP, and $19,000 \pm 2,000$ years BP, respectively (Schwarcz *et al.*, 1998). These dates have recently been criticised as under-estimated (Alpers *et al.*, 2000; Millard and Pike, 1999). ESR dating on tooth enamel from C1 produced much earlier dates of $112,000 \pm 29,000$ years BP and $143,000 \pm 38,000$ years BP, depending upon the uptake model used (Grün and Stringer, 2000). These dates suggested that Tabun C1 dated to either the end of MIS 6 or the beginning of MIS 5. These new dates also supported Garrod's original idea that it was either a burial into layer C from layer B, or a very late burial within layer C.

Tool industries

Stone tools were not very abundant in layer B, but the lithic assemblage contained a high proportion of finished implements, compared with the lower levels. Layer B lithics were categorised as Upper Levallois-Mousterian and included points, racloirs, end-scrapers, various other scrapers, burins, flakes (including Levallois), chisels, disks, hand-axes and cores (Garrod and Bate, 1937). Layer C contained a much more abundant tool assemblage, defined by Garrod and Bate (1937) as Lower Levallois-Mousterian. It included points, racloirs, various types of scrapers, burins, notched flakes, chisels, end-scrapers, disks, choppers, hand-axes, various retouched flakes and fragments, Levallois flakes, various blades and cores. Many of the tools and their accompanying debitage from Layer C had been cracked through contact with fire

(Garrod and Bate, 1937). This is consistent with the use of the cave as an occupational site.

Non-human fauna

Layer C

Non-human faunal remains were found within the cave and became more abundant towards its entrance, probably due to dissolution at the rear of the chamber. Garrod and Bate (1937) combined the faunal assemblages from layers C and D, due to their overwhelming similarity in composition. They identified the following: roe deer (*Capreolus capreolus*); red deer (*Cervus elaphus*); fallow deer (*Dama mesopotamica*); gazelle (*Gazella* sp.); steppe ass (*Equus hydruntinus*); wild ass (*Equus hemionus*); bovid (*Bos* sp.); hyaena (*Hyaena* sp.); wolf (*Canis lupus*); red fox (*Vulpes vulpes*); bear (*Ursus mediterraneus*); leopard (*Panthera pardus*); hippopotamus (*Hippopotamus amphibius*); wild boar (*Sus scrofa*); ibex/goat (*Capra* sp.), as well as a variety of rodents. The majority of these bones appeared to have been burnt and broken, possibly for food. There was a rapid increase in the dominance of gazelle in layer C, possibly indicating the onset of drier conditions.

Layer B

Layer B contained a large number of non-human faunal remains, which included: hyaena (*Hyaena hyaena*); red deer (*Cervus elaphus*); wolf (*Canis lupus*); fallow deer (*Dama mesopotamica*); red fox (*Vulpes vulpes*); ibex/goat (*Capra* sp.); leopard (*Panthera pardus*); bovid (*Bos* sp.); gazelle (*Gazella* sp.); wild ass (*Equus hemionus*); steppe ass (*Equus hydruntinus*); wild boar (*Sus scrofa*); roe deer (*Capreolus capreolus*), and a variety of rodents. This assemblage reflected a much more modern collection of species than those found in layers C and D. This difference suggests a significant climatic change between layers C and B, an increase in rainfall and a significant decrease in temperature (Garrod and Bate, 1937). The assemblage of layer B was heavily dominated by the remains of fallow deer, with very low numbers of small animals. All elements of the skeleton were present and this, combined with the small hearths in this layer, suggests the use of the site as a butchery station (Garrod and Bate, 1937), although later analysis suggest that these remains were accumulated largely by natural means (Garrard, 1982).

Flora

Sediment from both layers B and C were mainly composed of terra rossa soil and ash from wood-bark (Albert *et al.*, 1999). The ash component of layer B sediments was

very low, but they were much more variable in level C. Phytolith analyses confirmed that the ash component of layer B and C was derived from the burning of wood (Albert *et al.*, 1999), but it was not possible to determine the species of the trees used.

Hominin remains

Layer C contained the majority of hominin remains and most were deposited near the cave entrance. They included both cranial and post-cranial elements (Garrod and Bate, 1937), as well as seven teeth recently assigned to a single individual, Tabun BC7, from layer B (Coppa *et al.*, 2005). Of most interest to this current study were the remains of two individuals: Tabun CI and Tabun II. A description of these remains was made by Garrod and Bate (1937) and McCown and Keith (1939):

Tabun CI

This partial skeleton was discovered just outside the mouth of the cave on the western side of the terrace. It included a partial cranium, a mandible and a fragmented post-cranial skeleton. All of the teeth were still present within the maxilla and mandible, apart from the upper right third molar, which appeared to have been lost *post-mortem*. The skeleton was positioned on its back, slightly turned over to the left side, with the legs loosely flexed and the left arm bent at right angles to the chest. The upper part of the right humerus possessed a healed break at its distal end. This skeleton was situated so close to the surface of Level C that Garrod suggested it represented an intrusion from Level B. The most recent dates retrieved from this fossil seem to support this conclusion. This individual was identified as a lightly built adult female Neanderthal (Bar-Yosef and Callander, 1999; McCown and Keith, 1939; Schwartz and Tattersall, 2002b; Vandermeersch, 1992).

Tabun II

This individual was represented by six fragments of a mandible that were found scattered over a small area within Layer C on the eastern side of the site. Once reassembled these fragments formed a well-preserved and nearly complete mandible containing all of the lower teeth, apart from the left first incisor. Despite the presence of a possible chin, this mandible has often been classified as adult Neanderthal with a close affinity to Tabun CI, but more robust and probably male (Stefan and Trinkaus, 1998).

The teeth from both individuals showed evidence of substantial wear. The anterior teeth of Tabun CI possessed heavy wear, while the posterior teeth were moderately

worn. The teeth of Tabun II (apart from the third molars) were significantly more worn than those of Tabun CI, which possibly indicated a greater age for this individual. All showed large areas of exposed dentine with little enamel still present on their crowns.

7.2 Middle Palaeolithic Modern Humans



Figure 7.2.1: Middle Palaeolithic Modern Human and Neanderthal sites included in this study from Western Asia. 1. Qafzeh, 2. Skhul, 3. Amud, 4. Kebara, 5. Tabun, 6. Shanidar.

Qafzeh

The site of Jebel Qafzeh is a large limestone cave and terrace located in the Wadi el-Hadj, 2.5 km south of Nazareth, Israel (Fig. 7.2.1). The cave is situated 220m above sea level, containing a single rectangular chamber 21m long and 17m wide, a chimney and a large terrace directly in front of the entrance. Several periods of excavation took place during the twentieth century: first by Neuville and Stekelis between 1933 and 1935, who excavated the deposits within the cave (Neuville, 1951); and between 1965 and 1979 by Vandermeersch, Piveteau and Perrot, who focused mainly on the cave entrance and terrace (Perrot, 1968; Vandermeersch, 1981).

Deposits from the Upper and Middle Palaeolithic were revealed, with those from the Middle Palaeolithic associated with more substantial hominin occupation (Rabinovich *et al.*, 2004). These Middle Palaeolithic layers were approximately 4.5m thick and divided into two major accumulation units; an upper sequence (layers XVII-XXIV) and a lower

sequence (layers III-XV) (Vandermeersch, 1981). The upper sequence was the richest of the two accumulations, containing the majority of the hominin remains as well as hearths, numerous lithic artefacts, high concentrations of non-human faunal remains, shells and lumps of ochre (Hovers *et al.*, 2003; Tchermov, 1988). The remains of 16 hominins were discovered, two from the Upper Palaeolithic (Qafzeh 1 and 2), and 14 from the Middle Palaeolithic (Qafzeh 3-16).

Dating

Qafzeh 3-16 were discovered within layers XVII-XXIV and were originally dated, using microfaunal and lithostratigraphic evidence, to 80-100,000 BP (Bar-Yosef and Vandermeersch, 1981). However, the classification of the hominin remains as Early Modern Humans led to the suggestion of a younger date of c. 40,000 BP to accommodate a unilinear model of hominin evolution in the region, from Neanderthal to Modern Human (Jelinek, 1982a; Trinkaus, 1984b). Subsequently, burnt flint and animal remains associated with the hominin remains were dated using TL and ESR methods. TL produced a date of $92,000 \pm 5,000$ BP, and ESR produced average dates of $96,000 \pm 13,000$ BP and $115,000 \pm 15,000$ BP, depending upon either an early or linear uptake model (Schwarcz *et al.*, 1988; Valladas *et al.*, 1988). The Qafzeh 6 hominin was directly dated using gamma spectrometry to between $94,000 \pm 10,000$ BP and $80,000 \pm 24,000$ BP (Yokoyama *et al.*, 1997). The combination of these dating techniques, including the original micro-faunal and lithostratigraphic evidence, supports the presence of Early Modern Humans at the site of Qafzeh during MIS 5.

Tool technologies

The Middle Palaeolithic stone tool assemblage discovered at Qafzeh has been the subject of several specialised studies (Hovers and Raveh, 2000; McBrearty *et al.*, 1998; Shea, 1989) and comments (Jelinek, 1982a; Vandermeersch, 1981). The hominin bearing layers, XVII-XXIV, contained a Mousterian assemblage, characterised by the dominance of a centripetal flaking method, producing Levallois flakes and debitage (Hovers and Raveh, 2000; Vandermeersch, 1981). Scrapers and points were the dominant tool types and large oval flakes and racloirs were also common (Shea, 1989; Vandermeersch, 1981). It resembles the Levantine Mousterian of Tabun B and C (Jelinek, 1982a). Analyses of the raw material selections at Qafzeh suggest its inhabitants were not using locally available material, probably due to its low quality with possible alternative sources at least 10-12km to the northeast of the site (Hovers and Raveh, 2000; Shea, 1991).

Non-human fauna

The remains of red deer (*Cervus elaphus*), fallow deer (*Dama mesopotamica*), aurochs (*Bos primigenius*), gazelle (*Gazella* sp.), hartebeest (*Alcelaphus buselaphus*), ibex (*Capra ibex*), wild pig/boar (*Sus* sp.), horse (*Equus* sp.), rhinoceros (*Stephanorhinus hemitoechus*) and camel (*Camelus* sp.) were discovered within the Middle Palaeolithic deposits from the terrace (Bouchud, 1974). The layers inside the cave contained the remains of red deer, fallow deer, gazelle, horse, ibex/goat, hartebeest, wild pig/boar and bovids (*Bos* sp.) (Bouchud, 1974).

Flora

Analyses of stone tool wear patterns found a predominance of woodworking tools in the utilised assemblage, probably reflecting wooden tool manufacture and repair (Shea, 1989).

Hominin remains

The majority of the Middle Palaeolithic hominins were discovered in layer XVII, but were also found in layers XV and XXIII. All these remains have been classified as Early Modern Humans (Vandermeersch, 1981). Most of the skeletons were concentrated within an area of a few square meters in front of the cave entrance (Tillier *et al.*, 2004). Several of these individuals (Qafzeh 8, 9, 10 and 11) appear to have been the subjects of intentional burial. For example, the grave of Qafzeh 11, a child, had been dug into the bedrock and included possible grave goods; fallow deer antlers placed against the child's chest (Belfer-Cohen and Hovers, 1992; Vandermeersch, 1981). Another unusual feature of this collection of hominins is that the majority of them had failed to attain adulthood (Vandermeersch, 1981).

Four of the adult skeletons, described in Vandermeersch (1981), have been included in the current study.

Qafzeh 5

Whilst this partial skull was crushed and slightly distorted, part of the maxilla was preserved, containing the upper first molars, premolars, canines, second incisors and right first incisor. The skull lacked enough sexually dimorphic features to provide a reliable sex estimate, but the evidence from tooth wear and suture closure suggest that it belonged to a young adult of less than 30 years.

Qafzeh 7

Qafzeh 7 is comprised of a partial skull and mandible, as well as a fragmentary post-cranial skeleton. The maxilla included a complete dentition and the partial mandible was only missing the left third molar. The skull was too incomplete to be sexed, but the tooth wear and suture closure suggest this individual was a mature adult.

Qafzeh 9

The Qafzeh 9 hominin was represented by a complete, but fragmented and crushed skeleton. This individual appeared to have been buried in a semi-flexed position on its right side with possible grave offerings of deer antlers placed near the face and hands. All of the upper and lower teeth are preserved *in situ*. The tooth wear, combined with evidence from the pelvis and crania, suggest that this skeleton belonged to a young adult female.

Qafzeh 11

This individual was discovered in layer XII and was represented by an almost complete cranium and upper half of the post-cranial skeleton. The mandible lacked only the left third premolar and the right second molar was missing from the mandible. The dental development indicated an age between 12 and 14 years. However, despite the presence of unerupted third molars, the tooth wear suggests a slightly older age more similar to that of a young adult, such as Qafzeh 9. The skull showed evidence for an unhealed lesion in the cranial vault, as well as an infection within the mastoid process, involving two of the ear ossicles (Tillier *et al.*, 2004).

All four individuals showed only slight tooth wear, probably reflecting the young age of these individuals. The incisors were the most heavily worn teeth in the upper and lower dentition. No evidence of dental malocclusion, crowding, or abnormal spacing of teeth was found (Tillier *et al.*, 2004). Three of the teeth belonging to Qafzeh 11 showed evidence of linear enamel hypoplasias (Tillier *et al.*, 2004).

Skhul

The site of Mughareet es-Skhul (Cave of Kids) is situated in the Wadi el-Mughara on the western flank of the Mount Carmel Range, 19 km south of Haifa, Israel (Fig. 7.2.1). Despite its name, the majority of the site is made up of a rock-shelter and a terrace. The cave itself is relatively small in size, a single chamber 2.5m in diameter, and makes up less than a quarter of the site. McCown (1937) first excavated the site in

1931, uncovering three distinct stratigraphic units: layer A, containing a mixed assemblage of Natufian, Aurignacian and Mousterian tools; layer B, containing the remains of at least 10 hominins associated with Levallois-Mousterian lithic tools; and layer C, a shallow deposits containing a sparse Mousterian lithic assemblage. Layer B was the thickest of the three layers and contained the majority of the non-human fauna, lithics and hominin remains discovered at the site (McCown, 1937).

Dating

Several dating methods have been applied to layer B. Animal teeth were dated using ESR, providing mean ages of $81,000 \pm 15,000$ BP and $101,000 \pm 12,000$ BP, depending upon an early or linear uptake model (Grün and Stringer, 1991; Stringer *et al.*, 1989). The same specimens were dated using Uranium-series to 88-46,000 BP, and 102-166,000 BP, also depending upon an early or linear uptake model (McDermott *et al.*, 1993). TL techniques were applied to six burnt flints from layer B, producing a scatter of dates around 119,000 BP (Mercier *et al.*, 1993). Whilst these dating techniques produced a wide range of dates, most place layer B within MIS 5, suggesting the site of Skhul was broadly contemporary with the hominin bearing levels at Qafzeh.

Tool technologies

Over 9,000 lithic artefacts were recovered from within layer B (Shea, 1989). Although this thick layer was subdivided into two units, B1 and B2, both contained very similar tool industries, including points, racloirs, end-scrapers, burins, handaxes, notched flakes, chisels, squamous flakes, choppers, Levallois flakes, flakes, cores and hammerstones (Garrod and Bate, 1937). This assemblage is typical of the Levantine Mousterian, and its similarities to the Tabun level C assemblage were noted by McCown (1937).

In addition to the lithic artefacts, two shell beads have recently been identified within a small collection of marine shells (Vanhaeren *et al.*, 2006), originally described by Garrod and Bate (1937). Both shell beads were identified as *Nassaruis gibbosulus*.

Non-human fauna

The non-human faunal remains found within layer B were sparse and highly fragmented (Garrod and Bate, 1937). This prohibited the removal of the remains of many micro-fauna, but the excavators were able to identify the following macro-fauna: bovids (*Bos* sp.); fallow deer (*Dama mesopotamica*); ibex/goat (*Capra* sp.); gazelle

(*Gazella* sp.); hippopotamus (*Hippopotamus amphibius*); hartebeest (*Alcelaphus buselaphus*); wild ass (*Equus hemionus*); steppe ass (*Equus hydruntinus*); warthog (*Phacochoerus africanus*); wild boar (*Sus scrofa*); rhinoceros (*Stephanorhinus hemitoechus*); roe deer (*Capreolus capreolus*), and red deer (*Cervus elaphus*). It also included the remains of carnivores such as hyaena (*Hyaena* sp.), red fox (*Vulpes vulpes*) and wild cat (*Felis silvestris*) (Garrod and Bate, 1937). The assemblage was dominated by the remains of large bovids, but gazelle and fallow deer were also common (Garrod and Bate, 1937).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The remains of over 10 hominins were discovered during the excavation of the cave and terrace, and these varied greatly in their completeness and preservation. Unlike the hominin assemblage from Qafzeh, this collection was dominated by the remains of adults and mature adults (McCown and Keith, 1939). The positioning and articulation of many of the skeletons led the excavators to believe they represented intentional burials (McCown, 1937). Their concentration in the western part of the terrace also suggested that the site might have been used as a cemetery as well as a place of habitation.

Skhul V, one of the most complete of the Skhul skeletons, has been included in the present study.

Skhul V

This intentional burial contained the skeleton of an adult male c. 45 years old, and included a heavily reconstructed skull, missing most of the midfacial region, as well as a relatively complete mandible (McCown and Keith, 1939). This individual had been laid on his back, slightly inclined towards the right side and with the head bent upon the chest. The right arm was tightly flexed, with the left arm lying across the body and the legs tightly flexed across the pelvis. The mandible of a very large pig was found in the angle formed by the left forearm and right humerus, and appeared to have been a deliberate inclusion (McCown, 1937).

All of the upper teeth were preserved *in situ* and the mandible only lacked the right third premolar. All of the teeth, apart from the third molars, showed evidence for heavy

wear, exposing patches of dentine. The lingual surfaces of the incisors and canines also showed evidence for wear (Schwartz and Tattersall, 2002b). Schwartz and Tattersall (2002b) also suggested that wear on the lower M1s may have been exaggerated during the reconstruction of the skull.

7.3 Upper Palaeolithic and Early Epipalaeolithic Modern Humans

The top layer, level 1, was radiocarbon dated to $23,400 \pm 450$ BP and the bottom layer, level 14, to $33,320 \pm 410$ BP and $34,260 \pm 470$ BP (Movius 1958; Vogel & Waechter 1968).



Figure 7.3.1: Upper Palaeolithic and Early Epipalaeolithic Modern Human sites included in this study, from Europe, W. Asia and N. Africa. 1. Abri Pataud, 2. Dolní Věstonice, 3. Farincourt, 4. Isturitz, 5. Lachaud, 6. La Madeleine, 7. Le Placard, 8. Pavlov, 9. Ein Gev, 10. Ohalo & 11. Afalou-bou-Rhumel.

Abri Pataud

The site of Abri Pataud is a rock shelter and small terrace near the town of Les Eyzies d'Tayac, located on the left bank of the Vézère River in the Dordogne region of France (Fig. 7.3.1). It is situated 76m above sea level within a limestone cliff, forming part of an important collection of rockshelters and caves, including Lascaux and La Ferrassie. Movius (1958) excavated the site between 1958 and 1963, revealing approximately 9.25m of deposits. Fourteen levels of hominin occupation were discovered, containing high concentrations of artefacts dating from the lower Aurignacian to the Proto-Magdalenian (Bricker *et al.*, 1995; Movius, 1958; Movius, 1975). The remains of 13 hominins were discovered towards the top of these deposits, in level 2, associated with a Proto-Magdalenian industry.

Dating

The top layer, level 1, was radiocarbon dated to $20,400 \pm 450$ BP and the bottom layer, level 14, to $33,330 \pm 410$ BP and $34,250 \pm 675$ BP (Movius 1963; Vogel & Waterbolk 1963). Thirteen radio-carbon dates were also taken from level 2, giving an average age for the hominin remains of c. 22,000 BP (Bricker and Mellars, 1987).

Tool industries

Over 18,000 stone tools and pieces of debitage were collected from level 2 during the 1958 to 1963 excavations (Clay, 1995). The assemblage was dominated by backed bladelets and burins, with scrapers, points and cores occurring in high numbers (Clay, 1995). This industry also contained 180 tools made out of bone or antler, including awls, points and pins, as well as incised pieces, bone pendants and pierced teeth. One of the most notable finds was a concentration of 82 square-shaped, pierced reindeer bone pendants, discovered towards the back of the rockshelter and probably formed part of the same necklace or clothing decoration (Clay, 1995). Movius (1958) defined this industry as Proto-Magdalenian.

Non-human fauna

Reindeer (*Rangifer tarandus*) dominated the non-human faunal assemblage from level 2, comprising 85.5% of the total macro-fauna (Bouchud, 1975). Other species included, red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), bovids (*Bos* sp.), wild horse (*Equus caballus*), woolly mammoth (*Mammuthus primigenius*), ibex (*Capra ibex*), chamois (*Rupicapra rupicapra*), wolf (*Canis lupus*), red fox (*Vulpes vulpes*), lion (*Panthera leo spelaea*) and hare (*Lepus* sp.) (Bouchud, 1975). The micro-faunal assemblage contained various species of rodent, such as mouse and vole, as well as birds.

Concentrations of shells were found throughout the deposits at Abri Pataud. These included a mixture of pierced shells, non-marine shells, fossil shells and marine shells, but they did not occur in high enough numbers to suggest that they made a substantial contribution to the hominin diet (Dance, 1975).

Flora

Samples taken from the rock-shelter during the 1965 and 1967 excavations proved extremely poor in pollen, however, several species of tree were identified, including birch (*Betula*), pine (*Pinus*) and oak (*Quercus*), which are all indicative of steppe vegetation (Donner, 1975).

Human remains

The hominin remains from level 2 were mostly fragmentary, five individuals being only represented by isolated teeth, but all were classified as Modern Humans (Movius and Vallois, 1959; Schwartz and Tattersall, 2002b). These were spread over a large area, approximately 14 m² and included fragments of crania and post-crania, as well as complete long bones (Billy, 1975). The most significant of these finds was a complete skull and mandible, Abri Pataud 1. This individual has been included in the current study.

Abri Pataud 1

This skull and mandible are thought to represent the remains of a young adult female aged between 16 and 20 years (Billy, 1975; Movius and Vallois, 1959). All of the tooth sockets were preserved in the maxilla, but only the molars and the left premolars were present. The mandible also retained all of its tooth sockets, but only the molars and third premolars. The rest of the teeth appear to have been lost *post-mortem*. The teeth are only slightly worn with small patches of dentine exposed on all the teeth, apart from the third molars.

Farincourt

The site of Farincourt is comprised of four caves, located on the right bank of the River Rigotte near the town of Farincourt in the Haute-Marne region of France (Fig. 7.3.1). Although excavation of the caves began in 1878, it was not until Joffroy and Mouton's (1946) excavation of cave III in 1938 that hominin remains were discovered. Hominin remains were also discovered in Cave II, but these were highly fragmented (Joffroy and Mouton, 1956).

Dating

The stratigraphic sequence was not well established at this site, however, the cultural remains and depths of the deposits suggest a short occupancy during the Magdalenian period of Würm III/IV and the end MIS 2 (Oakley *et al.*, 1971).

Tool Industries

More than 450 worked and used pieces of stone, as well as hundreds of pieces of debitage, were found within the deposits of Caves I, II and III. The stone assemblage from each cave was very homogenous and their descriptions therefore combined. It contained a high number of microliths and was dominated by burins, blades and

bladelets (Joffroy and Mouton, 1946). It also included scrapers, borers, points and raclettes, as well as over 70 atypical retouched pieces. The bone and antler assemblage contained lissoirs, sticks, spears, points and awls, many of which had been polished. Pieces of ochre and perforated objects, such as shells were found throughout the site (Joffroy and Mouton, 1946).

Non-human fauna

Reindeer (*Rangifer tarandus*) remains dominated the non-human faunal assemblage from the caves, with woolly mammoth (*Mammuthus primigenius*) remains also being common (Joffroy and Mouton, 1946; Joffroy and Mouton, 1956). The remains of hyaena (*Hyaena* sp.), brown bear (*Ursus arctos*), red fox (*Vulpes vulpes*), arctic fox (*Alopex lagopus*), aurochs (*Bos primigenius*), bison (*Bison priscus*), chamois (*Rupicapra rupicapra*), horse (*Equus* sp.) and wolf (*Canis lupus*) were also found.

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The remains of three individuals were found within the cave deposits, including two adults, a male and a female, and the maxilla of a juvenile. Farincourt 1, the adult female, has been included in the current study.

Farincourt 1

This partial skeleton, a mandible and a right humerus, was found within the terrace deposits that lay directly in front of cave III. The mandible, belonging to a young adult, included an almost complete dentition, missing only the right third molar. The excavators discovered a perforated pendant directly below the skeleton, and suggested it formed part of an intentional burial (Joffroy and Mouton, 1946). The dentition exhibited moderate amounts of wear.

Isturitz

Isturitz is a large cave site within Mont de Castelou, near the village of Saint-Martin-d'Aberoue, 30 km southeast of Bayonne, France (Fig. 7.3.1). It is situated approximately 200m above sea level and comprises two main chambers, one to the south (Saint-Martin), and one to the north (Isturitz). The site was excavated between 1895 and 1939 by various investigators including Piette, Passemard (1922), and Saint-

Perrier and Saint-Perrier (1930;1936;1952). The deposits within the cave were divided into layers A-P, and were dominated by a brown bear (*Ursus arctos*) den, approximately 3.5m thick (Passemar, 1922). The hominin occupation layers date from the Bronze Age to the Mousterian, containing abundant evidence of domestic occupation, with hearths and a high number of non-human faunal material (Passemar, 1922). Hominin remains were found throughout the deposit, although they were largely concentrated within the Aurignacian layers.

Dating

The antiquity of the excavations meant that the site was not subjected to modern dating methods. Most layers were dated by their associated tool industries, non-human fauna and art objects. The layers containing the hominin remains included in this study were associated with an Aurignacian tool industry and can therefore be dated between 40,000 and 28,000 BP, and MIS 3.

Tool industries

The Aurignacian layers were clearly separated from those of the underlying Mousterian layers by the disappearance of the racloirs and the appearance of a high number of blades, bladelets and scrapers (Passemar, 1922). The tool assemblage was dominated by stone blades, grattoirs and burins, and included an abundant bone, ivory and antler tool industry of spatulas, Aurignacian points, pendants and awls (Passemar, 1922;St-Pèrier and St-Pèrier, 1952).

Non-human fauna

Wild horse (*Equus caballus*) remains dominated the non-human faunal assemblage, with those of reindeer (*Rangifer tarandus*), red deer (*Cervus elaphus*), wolf (*Canis lupus*) and red fox (*Vulpes vulpes*) also being common. The assemblage also included the remains of large bovids (*Bos* sp.), woolly mammoth (*Mammuthus primigenius*), hyaena (*Hyaena* sp.), roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*), brown bear (*Ursus arctos*), cave bear (*Ursus spelaeus*), wild cat (*Felis silvestris*), woolly rhinoceros (*Coelodonta antiquitatis*) and several species of bird (St-Pèrier and St-Pèrier, 1952).

Flora

The only information regarding flora this site demonstrates that ash from the hearths in the Aurignacian layers came from wood (Passemar, 1922).

Hominin remains

The hominin remains from Isturitz are fragmentary and, though never formally described, have always been regarded as fully modern *Homo sapiens* (Schwartz and Tattersall, 2002a). Many of the cranial fragments show evidence of cut marks, which the excavators believed were the actions of stone tools (St-Pèrier and St-Pèrier, 1952). Two individuals from the Aurignacian levels have been included in the current study.

Isturitz series 7B

This nearly complete mandible of an adult male, aged between 20 and 30 years, was found towards the centre of the cave amongst a collection of fragments from four or five individuals (St-Pèrier and St-Pèrier, 1952). Seven teeth remain *in situ*: the second and third molars; the right first molar; the right third premolar and the right second incisor. The black colouring on part of the mandible suggests that it may have burnt by fire. It also possessed several cut marks, similar to those found on the non-human faunal bones. All of the remaining teeth within the adult mandible are heavily worn, except for the third molars. A large amount of dentine has been exposed on the other teeth. There is also evidence for abscessing around the alveolar of the lower first molar, which was not present itself (St-Pèrier and St-Pèrier, 1952).

Isturitz 71

This individual is represented by the upper palate of a maxilla, containing all of the upper tooth sockets. However, only the first and second molars and the right third molars are present *in situ*. The first molars are moderately worn, while the second molars and third molar are only slightly worn. There were not enough diagnostic features preserved to provide a reliable sex estimate.

Lachaud

Lachaud is one of three sites, known as the Pouget caves, located in Terrasson near the Vézère river within the Dordogne region of France (Fig. 7.3.1). It is comprised of a cave, rockshelter and terrace. Cheynier (1949;1953;1965) undertook major excavations between 1941 and 1944, revealing six layers within these deposits; three from the Proto-Magdalenian (1-3) and one from the Solutrean (6) period (Cheynier, 1949;1953;1965). The remains of at least eight hominins were discovered within the Proto-Magdalenian layers and associated with well-used hearths, non-human fauna, charcoal, tools made from stone, bone and antler, and representational art (Ferembach, 1957;1965).

Dating

The hominin-bearing layers were dated using the associated Proto-Magdalenian assemblage to MIS 2 (Würm III/IV) (Oakley *et al.*, 1971)

Tool industries

The Proto-Magdalenian industry contained tools made from stone, bone and antler. The stone assemblage was dominated by raclettes but also included burins, blades, bladelets, scrapers and points, predominantly made on flakes (Cheynier, 1965). The worked bone and antler assemblage contained needles, spatulas, points, burins and awls, as well as retouched fragments (Cheynier, 1949).

Non-human fauna

The non-human faunal assemblage from the Proto-Magdalenian layers was dominated by the remains of reindeer (*Rangifer tarandus*) with red fox (*Vulpes vulpes*) also common. The rest of the assemblage was comprised of hare (*Lepus* sp.), wolf (*Canis lupus*), wild horse (*Equus caballus*), red deer (*Cervus elaphus*) and saiga antelope (*Saiga tatarica*), as well as fish, bird and sea shells (Cheynier, 1965). Many of these seashells were found in small concentrations, often pierced and mixed with pierced animal teeth, both representing pendants and beads. One collection of Nerina shells, for example, appear to have once formed a necklace (Cheynier, 1965).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The hominin remains were found within a small concentration towards the centre of the cave, representing two adults, one adolescent and five children, all Modern Humans (Ferembach, 1957;1965). They included a collection of cranial fragments, isolated teeth, two mandibles and the shaft of a tibia. Their location, the preservation of predominantly cranial pieces, and the presence of cut marks on many of the bones, led Ferembach (1957;1965) to conclude they were the subject of secondary burial. Both of the mandibles, Lachaud 3 and 5, have been included in the current study.

Lachaud 3

This well-preserved mandible of a young adult female, aged between 17 and 18 years, retains all of its molars and the sockets for the rest of the dentition (Ferembach, 1965). The molars are only slightly worn, with very small patches of dentine exposed on the

occlusal surface of the first and second molars. Several scratch marks were identified on the external surface of the mandible.

Lachaud 5

This individual is represented by two cranial fragments and a nearly complete mandible, including a complete dentition. The third molars were unerupted, suggesting an age of between 13 and 14 years (Ferembach, 1957;1965). However, while estimated to be younger than Lachaud 3, the first molars are more heavily worn, exposing larger and more numerous patches of dentine with the incisors moderately worn.

La Madeleine

The site of la Madeleine is a rockshelter near the town of Tursac, located on the right bank of the Vézère River within the Dordogne region of France (Fig. 7.3.1). It was excavated over several periods; firstly by Lartet and Christy in 1863, then by Girod, Massénat and River, and finally by Peyrony and Capitan between 1910 and 1926 (Capitan and Peyrony, 1928). The deposits were divided into three main levels (inferior, medium and superior) and were all attributed to the Magdalenian. They contained hearths, non-human fauna, tools made from stone, bone, ivory and antler, as well as art objects, personal ornaments and the remains of four hominins.

Dating

The site was originally dated using the associated cultural material to the Magdalenian and the Würm IV period of MIS 2 (Oakley *et al.*, 1971). More recently, the superior level has been radiocarbon dated to $12,640 \pm 260$ BP (Delpech, 1983). One of the burials, La Madeleine 4, was directly dated by AMS radiocarbon methods to $10,190 \pm 100$ BP (Vanhaeren *et al.*, 2004). This places these deposits towards the end of MIS 2.

Tool industries

The Magdalenian stone tool assemblage was dominated by burins, with numerous scrapers, and also included blades, bladelets, points, cores, hammers, grinding stone, pestles and mortars (Capitan and Peyrony, 1928). Tools made from bone, ivory and antler were also common and included harpoons, tridents, throwing spears, points, chisels, handles and spatulae.

Non-human fauna

The remains of reindeer (*Rangifer tarandus*) and hare (*Lepus* sp.) dominated the non-human faunal assemblage from La Madeleine. It also contained the remains of brown bear (*Ursus arctos*), wolf (*Canis lupus*), lynx (*Lynx lynx*), red fox (*Vulpes vulpes*), wild horse (*Equus caballus*), wild boar (*Sus scrofa*), large bovids (*Bos* sp.) and chamois (*Rupicapra rupicapra*), as well as rodents, a number of different bird species and shells (Capitan and Peyrony, 1928).

Some of the animal teeth, bone and shellfish had been pierced, probably representing personal ornamentation. For example, the burial of the La Madeleine 4 infant was associated with pierced objects, including 1314 dentalium shells, clustered around the head, neck, elbows, wrists, knees and ankles (Capitan and Peyrony, 1928; Vanhaeren *et al.*, 2004). Many of the ivory, antler and bone objects had been engraved or sculpted into representations of animals.

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The remains of three adults and one child were discovered during the excavations at La Madeleine, and are all Modern Humans (Capitan and Peyrony, 1912; Lartet and Christy, 1864). The most complete of the adults was La Madeleine 1, and this has been included in the current study.

La Madeleine 1

This adult was represented by fragments of skull, mandible and post-crania (Lartet and Christy, 1864). Unfortunately the skeleton was too fragmentary to provide a reliable sex estimate. The mandibular fragment contained the left first and second molar, as well as the third premolar. These three teeth were moderately to heavily worn.

Le Placard

The site of Le Placard is comprised of a cave and rockshelter near the town of Rochebertier within the Charente region of France (Fig. 7.3.1). Maret excavated the site between 1880 and 1883, and its deposits were divided into two levels, one from the Solutrean and three from the Magdalenian (Breuil and Obermaier, 1909).

Approximately 21 individuals were discovered within these layers, some of which may represent intentional burials (Oakley *et al.*, 1971).

Dating

The site was dated using the associated tool assemblages to the Würm III/IV interstadial and MIS 2 (Oakley *et al.*, 1971)

Tool Industries

The hominin remains were associated with a tool assemblage characteristic of the Solutrean and Magdalenian, but these industries have never been formally described (Oakley *et al.*, 1971). The site is most well known for its bone and antler industry, which includes points, awls, haft straighteners and notched artefacts.

Non-human fauna

It was not possible to find published information on animal remains from this site.

Flora

It was not possible to find published information on plant remains from this site.

Hominin Remains

The hominin remains, all considered to be fully Modern Human, are comprised mainly of skull fragments. Many of these fragments showed evidence for intentional cut marks and impact scars from stone implements (Breuil and Obermaier, 1909). Five of these individuals, le Placard 26, 28, 32, 42 and 43, have been included in the current study.

Le Placard 26

This individual is represented by an almost complete mandible, including the second molars, left first molar, left fourth premolar, right canine, second incisors and left first incisor. These teeth show only slight wear, with small patches of exposed dentine.

Le Placard 28

Le Placard 28 is comprised of part of the maxilla with all the tooth sockets but only the first molars, left second molar and right third molar present. The first molars are moderately worn, with the second and third molars showing only small amounts of wear.

Le Placard 32

A fragment of maxilla represents this individual, including the right first and second molar and the fourth premolar. The second molar is only slightly worn, while the fourth premolar and first molar are more heavily worn, exposing large patches of dentine.

Le Placard 42

Le Placard 42 is represented by the right part of a mandible, including the first and second molar, as well as the premolars and canine. All of these teeth are heavily worn, each exposing large patches of dentine.

Le Placard 43

This individual is represented by the fragments of a mandible, including the right molars. The first and second molars are heavily worn, however, only the cusps of the third molar have been worn away, with no exposed patches of dentine.

Dolní Věstonice

Two open-air occupation sites make up the site of Dolní Věstonice, and these are located at the base of the northern slope of the Pavlov Hills in southern Moravia, Czech Republic (Fig. 7.3.1). They form part of an 8 km chain of settlements extending between the modern villages of Dolní Věstonice and Bulhary, including the contemporary site of Pavlov. Site I was excavated by various teams between 1924 and 1979, revealing a richness of bone and stone implements, pieces of art that included portable female and animal clay figurines, bone carvings and decorations, elaborate settlement structures, and abundant non-human faunal remains, such as large accumulations of mammoth bones (Absolon, 1927; Klíma, 1963a; Klíma, 1969; Svoboda, 2006a; Vandiver *et al.*, 1990; Vlček, 1991). Site II is situated 1 km northwest of site I, and was excavated between 1985 and 1991. It is less abundant in archaeological artefacts than site I, but included hearths, non-human faunal remains, pieces of ochre, stone and bone tools, and objects of personal ornamentation (Klíma, 1988).

Both sites have yielded a large number of hominin remains; at least 35 individuals have been discovered, of which six were found within graves. An exceptionally well-preserved triple burial was discovered in 1986, at site II (DV 13, 14, and 15) (Jelíněk, 1992; Klíma, 1988; Svoboda, 2006b). A year later a single burial was discovered on the western slope of site II (DV 16), next to an occupational hearth (Svoboda, 1988; 2006b).

Dating

Both sites have been dated using radiocarbon methods. The lower deposits at site I were dated to 29,300 + 750/-690 BP and 27,250 +590/-570 BP, and the upper deposits to 25,950 +630/-580 BP (Svoboda, 1991a;Svoboda, 1995). Similarly, dates from site II provided a time range of between 29,000 and 26,000 BP (Svoboda, 1988). Charcoal found within the triple burial was dated from 27,660 ± 80 BP to 26,640 ± 110 BP (Klíma, 1988;Viček, 1991;Viček, 1992), and from the single burial, DV16, to 25,570 ± 280 BP (Svoboda, 1995). These dates place the site towards the end of MIS 3 and the beginning of MIS 2.

Tool industries

The hominin remains from site II were associated with a lithic assemblage characteristic of the Pavlovian, an Eastern Gravettian culture from the Upper Palaeolithic. Dominated by burins, it also included end-scrapers, backed microblades and backed micro-denticulates (Svoboda, 1988;Svoboda, 1991a). A bone and ivory industry was also present, including spatulas, points, awls and a large number of mammoth bones that had been split and re-shaped (Svoboda, 1991a). The majority of the lithic raw material, which included both flint and radiolarite, is non-local and appears to have been transported from sources 200km to the north of the Czech Republic as well as from sources in southern Poland (Klíma, 1963a;Svoboda, 1991a).

Non-human fauna

The non-human faunal assemblages from Dolní Věstonice I and II were dominated by the remains of woolly mammoths (*Mammuthus primigenius*). It has been suggested that these large concentrations, each containing 30-85 individuals, represented dwelling structures (Klíma, 1969;Klíma, 1983) or butchery sites (Svoboda *et al.*, 2005). The remains of reindeer (*Rangifer tarandus*), horse (*Equus* sp.), wolf (*Canis lupus*), arctic fox (*Alopex lagopus*) and arctic hare (*Lepus arcticus*) were also present (Svoboda *et al.*, 2005). It has been suggested that the high number of small carnivores at site II represented systematic fur and hide working (West, 2001). This has been supported by use-wear analyses of tools from the site (Šajnerová, 2001).

Flora

Pollen analyses of samples from Dolní Věstonice II identified the remains of species indicative of a forest-steppe environment, such as grasses (*Poaceae*/*Gramineae*), sedges (*Cyperaceae*), mugworts (*Artemisia* L.) and scattered junipers (*Juniperus* L.) (Svoboda, 1991b;Svoboda, 1991c). A variety of tree species were also identified,

mostly from wood charcoal in hearth deposits, including conifers and deciduous trees, indicating a cool continental climate (Klíma, 1963a; Mason *et al.*, 1994; Svoboda, 1991c). The presence of roots and tubers, a possible supply of starch, was also noted within the samples (Mason *et al.*, 1994).

Hominin remains

The site of DV II has provided a series of isolated fragments of hominin remains, representing at least seven individuals. However, it is the burials that have received most attention. All of the skeletons from the triple burial, DV 13, 14 and 16, lay side-by-side in an extended position, and were covered in red ochre (Alt *et al.*, 1997; Svoboda, 2006b). Kinship analysis of non-metric traits exhibited by these skeletons suggests that these three individuals were genetically related and may have belonged to one family (Alt *et al.*, 1997). DV13, 14, 15 and the single burial DV16 have all been included in the current study,

Dolni Vestonice 13

This individual, probably male, was buried on its back with the arms extended towards DV15, and the hands placed below DV15's pelvis amongst a concentration of red ochre (Bružek *et al.*, 2006; Klíma, 1988). The skull had been circled with pendants of pierced arctic fox and wolf teeth, and mammoth ivory (Klíma, 1988). This adult was aged between 21 and 25 years, by Hillson *et al.* (2006), based on several parts of the skeleton. The mandible contained a complete dentition, although the maxilla lacked six teeth: the right third premolar, canine and incisors, and the left fourth premolar. The remains of a thick pole were found stuck deep into the hip up to the coccyx and may have represented the cause of death (Klíma, 1988).

Dolni Vestonice 14

This young adult, probably male, was buried in a prone position (face down) with the skull circled with pendants (Bružek *et al.*, 2006; Klíma, 1988). The developmental markers in the skeleton suggested an age of late teens (Hillson *et al.*, 2006). The dentition was complete.

Dolni Vestonice 15

This individual was the centre skeleton from the triple burial. Its bones showed a number of pathological abnormalities, such as frontal asymmetry, uneven length of the lower limbs, a deformed right femur and scoliosis of the spine with left curvature, all of which indicate severe systematic stress during the first years of life (Formicola *et al.*,

2001; Klíma, 1988; Trinkaus *et al.*, 2001). These severe pathological changes make it too ambiguous to assign the individual a sex (Bružek *et al.*, 2006). The development of the skeleton and the tooth wear suggested an age at death of early thirties (Hillson *et al.*, 2006). A fragment of charred horse rib was found within the mouth. The maxilla contained a complete dentition and the mandible lacked only the left incisors.

Dolní Věstonice 16

This individual was buried in a very shallow grave on its right side, with strongly flexed knees. It represents the remains of an adult male aged between 45 and 50 years (Bružek *et al.*, 2006; Hillson *et al.*, 2006; Svoboda, 1988). Several healed traumas were observed on the skull. The mandible lacked the third molars, whilst the maxilla lacked the upper incisors and right canine. The burial was associated with four perforated carnivore canines, and the head and pelvic area were covered with red ochre (Svoboda, 1988).

Despite the young age of the individuals from the triple burial, most of their teeth were heavily worn (Svoboda, 1988). The buccal surfaces of the molars and premolars also showed evidence of wear. The dentition of DV15 possessed several clear developmental defects, such as dental enamel hypoplasia and a supernumerary tooth under the lower left third premolar (Trinkaus *et al.*, 2001). The crowns of DV 16's anterior teeth were almost completely removed through wear, and many of the molars were so heavily worn that the roots had become separated (Viček, 1997). The anterior teeth also showed evidence of labial rounding.

Pavlov

The open-air site of Pavlov is located at the base of the northern slope of the Pavlovské Hills in southern Moravia, Czech Republic, approximately 500m from the site of Dolní Věstonice (Fig. 7.3.1). Klíma (1954;1959;1963b) excavated the site between 1952 and 1972, revealing dwelling structures with central hearths and pits within and surrounding their floors (Svoboda, 1994). Clay figurines of animals and humans, carvings and a single male burial were also discovered at the site (Klíma, 1964; Svoboda, 2006b; Viček, 1962).

Dating

Six radio-carbon dates were obtained from wood charcoal found within the site's main occupational layers, with a range between 26,980 and 24,870 BP (Adovasio *et al.*,

1996; Klíma and Kukla, 1963; Svoboda and Škrdlá, 1997). These dates place the site at the end of MIS 3 and the beginning of MIS 2, contemporary with sites I and II at Dolní Věstonice.

Tool industries

Almost 1,000 lithic artefacts were retrieved during excavations at Pavlov (Svoboda, 1994). These were dominated by burins and backed implements but also included end-scrapers, other types of microliths, retouched blades, pointed blades and side scrapers. All of these pieces are typical of the Pavlovian culture, a variant of the Eastern Gravettian techno-complex. A tool type unique to Pavlov was the crescent, a non-backed implement that formed part of the microlithic group (Svoboda, 1994). The pronounced microlithic character of this assemblage, combined with the high proportion of retouched tools, suggest a high intensity of use (Svoboda, 1994). Most of the raw materials used to produce these tools were imported over long distances from flint sources in the north of the Czech Republic, while other material came from local outcrops (Svoboda, 1994). The bone industry from Pavlov was comprised of a high number of both finished and unfinished implements made from animal bone, ivory and antler. They were typical of the Pavlovian stage of the Gravettian and included decorative objects, such as headbands, relief pendants, and anthropomorphic as well as zoomorphic carvings (Svoboda *et al.*, 2000).

Non-human fauna

The non-human faunal assemblage from Pavlov were dominated by arctic fox (*Alopex lagopus*), hare (*Lepus* sp.) and wolf (*Canis lupus*), but also included the remains of other foxes (*Vulpes vulpes*), woolly mammoth (*Mammuthus primigenius*), reindeer (*Rangifer tarandus*), horse (*Equus* sp.), wolverine (*Gulo gulo*), various species of bird, and very small numbers of bovid (*Bos* sp.), bear (*Ursus* sp.) and lion (*Panthera leo spelaea*) (Musil, 1955).

Flora

Four pieces of fired clay from Pavlov bear impressions of textiles or flexible basketry fragments, representing the oldest indication of a fibre-based technology in the world (Adovasio *et al.*, 1996).

Hominin remains

The remains of a single burial, two isolated fragments of hominin jaws and two isolated teeth were discovered at the site of Pavlov (Klíma, 1997) . They represent the remains of Modern Humans and have all been included in the current study.

Pavlov I

The skeleton of this adult male, aged between 40 and 50 years, was discovered at the site of Pavlov (Hillson *et al.*, 2006;Viček, 1962). It included an almost complete and well-preserved dentition, only missing the upper left first incisor, the upper third molars and the lower right third premolar. The dentition was heavily worn, exposing dentine on all occlusal surfaces, with only a thin ring of enamel still remaining on many of the teeth. Wear was also observed on the labial surface of the anterior teeth and on the buccal surfaces of the molars and premolars (Viček, 1997). Wear was more pronounced in the upper teeth and on those from the left-side of the mandible and maxilla. Viček (1997) suggested that the long-term inclusion of flat pebbles in the mouth to bring on salivation and suppress thirst may have caused this unusual pattern (Viček, 1997).

Pavlov 2

These dispersed fragments of maxilla and mandible, as well as several isolated teeth belonging to a young adult, were discovered within close proximity to the Pavlov I burial (Hillson *et al.*, 2006;Svoboda, 2006b). They all belonged to an adult individual, and included the upper first and second molars, as well as the fourth premolars and right third premolar. They all showed moderate to heavy wear.

Pavlov 3

The remains of this adult included a portion of the right part of the mandible with the right first molar, premolars and canine, and an isolated left second molar. All of the teeth were heavily worn, and wear was also present on the lingual surface of the third premolar.

Ein Gev

A collection of open-air sites were discovered at the foot of the Golan Heights near Kibbutz Ein Gev on the eastern side of the Sea of Galilee (Fig. 7.3.1). They are approximately 46m above sea level and 500m from the shore of the Sea of Galilee. Stekelis and Bar-Yosef excavated these sites between 1963 and 1971 (Bar-Yosef,

1973;Stekelis and Bar-Yosef, 1965). Three burials were discovered: two in association with a Kebaran industry, Ein Gev 1 and Ein Gev 2; and one associated with a Late Aurignacian industry, Nahal Ein Gev 1. Only Nahal Ein Gev 1 retained a sufficient number of teeth to be included in the current study.

Dating

Radiocarbon dates proved impossible to retrieve from the Nahal Ein Gev 1 skeleton due to the small amount of organic material on the bones. Its date was therefore based on the typology of the lithic tool assemblage, the form of the burial and the affinities of the hominin remains to the Late Aurignacian and the end of MIS 3 c.30,000 BP (Bar-Yosef, 1973).

Tool industries

The lithic assemblage associated with Nahal Ein Gev 1 has never been formally described, but was similar to that of the final stages of the Levantine Aurignacian (Bar-Yosef, 1973). The technique of percussion was also typical of this late stage of the Upper Palaeolithic.

Non-human fauna

It was not possible to find published information on animal remains from Nahal Ein Gev 1.

Flora

It was not possible to find published information on plant remains from Nahal Ein Gev 1.

Hominin remains

Nahal Ein Gev 1

This burial contained the strongly flexed skeleton of an adult female aged between 30 and 35 years (Arensburg, 1977). The skull had been broken into many pieces and the mandible was also broken and missing part of the right side (Arensburg, 1977). The maxilla was heavily damaged, causing the loss of many of the upper teeth. However, the first and second molars, as well as the left premolars and canine, were still present *in situ*. The mandible retained only the first and second molars, and the left premolars. The surviving upper and lower teeth were heavily worn (Arensburg, 1977).

Ohalo II

Ohalo II is an open-air site, covering an area of approximately 1,500 m², and is located 212.5m below sea level on the western shore of the Sea of Galilee, near the city of Tiberias in northern Israel (Fig. 7.3.1). The site was first identified in 1989 and excavated during three main seasons, covering an area of over 300 m² (Nadel and Werker, 1999). The remains of three huts, one grave, several hearths and pits and a stone installation were found at the centre of the site (Rabinovich and Nadel, 1995). The huts contained a wealth of remains on the floors, including animal bones, flint tools and burnt fruits and seeds (Nadel and Werker, 1999).

Dating

Twenty-six samples of charcoal, taken from eight different locations, were radiocarbon dated, producing an average date of 19,430 ± 770 BP (Carmi and Segal, 1992; Hedges *et al.*, 1992; Kislev *et al.*, 1992; Nadel, 1990; Nadel *et al.*, 1995; Nadel and Hershkovitz, 1991). This date, combined with the tool assemblage, places the site of Ohalo II at the end of the Upper Palaeolithic and the early phase of the Kebaran in MIS 2.

Tool industries

The stone tool assemblage was made predominantly from flint and was extremely well preserved. It centred on the production of bladelets from single-platform cores and was dominated by microliths, but also included burins, endscrapers, awls, notches, Falita points, and retouched flakes and blades (Nadel, 1990; Nadel and Hershkovitz, 1991). Large quantities of debitage and debris, such as cores, suggest that both knapping and re-sharpening activities took place at the site (Nadel, 1990). The deposits at Ohalo also contained a large number of bone tools, dominated by points but also including awls (Rabinovich and Nadel, 1995).

Non-human fauna

The non-human faunal assemblage was very abundant and the remains of fallow deer (*Dama mesopotamica*), red deer (*Cervus elaphus*), aurochs (*Bos primigenius*), gazelle (*Gazella* sp.) and red fox (*Vulpes vulpes*) were among some of the species identified (Rabinovich and Nadel, 1995). The assemblage also contained the remains of various species of birds, rodents and reptiles. However, the assemblage was dominated by the remains of fish, which would have played an important role in the inhabitants' diet (Nadel and Hershkovitz, 1991).

Flora

The huts, hearths and pits all contained well preserved organic materials, including over 30 species of plants and large quantities of wild barley, emmer wheat and various fruits (Nadel and HersHKovitz, 1991; Piperno *et al.*, 2004). Analyses of the remains also suggested that: grasses were used for bedding (Nadel *et al.*, 2004); wood, stems, and leaves were used as fuel for fires (Nadel *et al.*, 2006); seeds and fruit were consumed (Kislev *et al.*, 1992; Weiss *et al.*, 2005); and soft tissue, such as fibres, were used to make string, cords, and probably baskets and fishing nets as well (Nadel, 1994; Nadel and Zaidner, 2002). The seasonal diversity of these floral remains suggests that the site's inhabitants were semi-sedentary (HersHKovitz *et al.*, 1995).

Hominin remains

The remains of four individuals were discovered at the site: the almost complete skeleton of an adult; the body of an adult mandible; fragments of two humeri; and a clavicle (HersHKovitz *et al.*, 1995). Two of these individuals have been included in the current study.

H2

This well preserved skeleton was found in a shallow pit, lying on its back with the hands crossed over the chest and the legs fully flexed towards the left side (Nadel, 1994). The head rested on three small stones, elevating it slightly above the body. The robustness of the skeleton, as well as features of the pelvis, strongly suggested that this individual was male. The advanced tooth wear estimate an age of between 30 and 40 years (HersHKovitz *et al.*, 1995; Karasik *et al.*, 1998; Nadel, 1994). The post-cranial skeleton was also indicative of this advanced age, as evidenced by: the ossification of the lower costo-vertebral cartilage; degenerative changes in some of the joints; and morphological asymmetry between the left and right upper limbs (HersHKovitz *et al.*, 1995). A possible grave good, an incised bone fragment, was discovered by the head. The teeth were heavily worn with the first maxillary molars possessing extremely steep oblique wear, and the upper and lower second and third molars showing evidence for cupping of the dentine (HersHKovitz *et al.*, 1995). The left upper third molar and three upper incisors were absent.

The mandible

This individual has received much less attention than the H2 skeleton, but is represented by the body of a mandible missing three incisors, the left canine and third

premolar. All of the other teeth showed moderate to heavy wear, with the first molars being the most worn.

Afalou-bou-Rhummel

The site of Afalou-bou-Rhummel (the cave of the sand) contains a cave and large rockshelter (Fig. 7.3.1). They are located approximately 40m above sea level within a cliff north of Traziboun and 3 km east of the Oued Agrioun in the Dour region of Beni-seghoual, Algeria. Arambourg (1929;1934) excavated the site over several seasons between 1928 and 1930, uncovering five main levels of deposits: 1-5. Large collections of hominin remains were discovered in a possible ossuary at the base of level 1, and two individuals were found in level 3. Hachi (1996) re-excavated the site between 1983 and 1993, discovering nine more individuals in the equivalent of Arambourg's levels 1 and 3, as well as finding lithics, bone tools and a collection of figurines.

Dating

The site was originally radiocarbon dated to c. 12,500-10,500 BP (Vallois, 1969), however, radio-carbon dates acquired during the more recent excavations age the site between $13,120 \pm 370$ BP and $11,450 \pm 230$ BP (Hachi, 1996), and towards the end of MIS 2.

Tool industries

The tool industry from Afalou was defined as Iberomaurusian (Hachi, 1996) and, while sparse in some areas, was characterised by the predominance of microlithic flint backed bladelets of La Mouillah type (Arambourg *et al.*, 1934). It also included notched blades, scrapers on blades and burins. Bone tools and personal ornaments were rare, but included awls, needles and beads.

Non-human fauna

The non-human faunal assemblage from level 1 was dominated by the remains of sea molluscs. It also included the sparse remains of Barbary sheep (*Ammotragus lervia*) (Arambourg, 1929). Contrastingly, levels 2 and 3 were dominated by the remains of Barbary sheep and contained the remains of aurochs (*Bos primigenius*), gazelle (*Gazella dorcas*), wild boar (*Sus Scrofa*), jackals (*Canis aureus*), fox (*Vulpes vulpes*) and brown bear (*Ursus arctos*) (Arambourg *et al.*, 1934).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The remains of more than 50 individuals were discovered by Arambourg (1934), including 26 males, 14 females and six juveniles. Two of these individuals, an adult and a juvenile (Afalou 28 and 16), were discovered in level 3, whilst all others were found at the base of level 1. The remains were tangled together in a mixture of positions within what appears to be a circular mass grave towards the centre of the cave, corresponding to the shape and orientation of the chimney above (Arambourg *et al.*, 1934). Arambourg (1929;1934) suggested that these bodies were intentionally deposited through the chimney into the cave. Five individuals have been included in the current study.

Afalou 1

This skeleton, of a young adult, lay on its left side with the legs slightly flexed (Arambourg *et al.*, 1934). The mandible lacked two incisors and the maxilla lacked the central incisors and the left third premolar. Both upper central incisors appear to have been lost *ante-mortem*.

Afalou 3

This skeleton, of an adult female, had been buried on its back with the legs tightly flexed towards the chest and the feet resting just below the pelvis (Arambourg *et al.*, 1934). The left arm was bent and the skull of a young child had been placed on top, leading to suggestions that this female had been buried with an infant in her arms (Arambourg *et al.*, 1934). The mandible included an almost complete dentition, missing only the left third molar, and the maxilla lacked the right third molar, right fourth premolar, left third premolar and three incisors. The upper incisors and right fourth premolar all appear to have been lost *ante-mortem*.

Afalou 10

This nearly complete skeleton of an adult male showed evidence for a healed fracture of the right radius and ulna (Hadjouis, 2002). The mandible lacked the incisors and the left canine.

Afalou 13

This almost complete skeleton, of an adult female, lacked only the lower arms and hands (Arambourg *et al.*, 1934). It lay on its right side with the skull facing towards the left and the legs slightly flexed. The mandible contained a complete dentition, while the maxilla was missing the upper central incisors, which appear to have been lost *ante-mortem*.

Afalou 28

The skeleton was found in level 3, lying on its back in an extended position with the head facing towards the left (Arambourg *et al.*, 1934). All of the bones, except for the mandible, appear to have been in full articulation. The skull of a child was discovered next to the feet, and flint pebbles were present beneath the skull. This individual appeared to have been intentionally buried. The mandible contained a complete dentition and the maxilla lacked three incisors, all of which appear to have been lost *ante-mortem*.

The dental extraction of the upper incisors was common not only within the adult permanent dentition at Afalou, but also the deciduous teeth of children (Hadjouis, 2002). One or several of the upper incisors were removed from all adults around the age of 16 years (Arambourg *et al.*, 1934). The teeth showed a pattern of heavy wear, with the lower incisors being the least worn; probably the result of the removal of their upper counterparts. Arambourg *et al.* (1934) noted that the upper teeth were generally more worn than their lower counterparts and that the cranial asymmetry observed in several of the Afalou specimens was associated with an asymmetrical pattern of wear (Hadjouis, 2002). Many of the individuals showed evidence of dental caries (Arambourg *et al.*, 1934;Hadjouis, 2002).

7.4 Late Epipalaeolithic Modern Humans

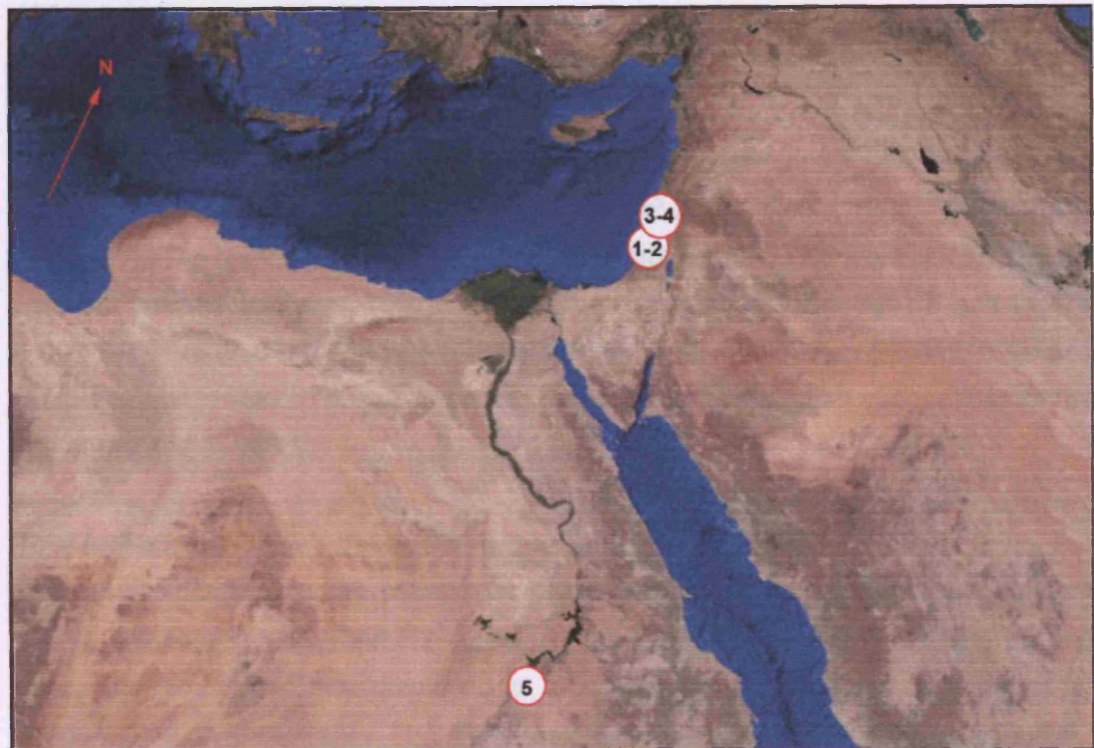


Figure 7.4.1: Late Epipalaeolithic Modern Human sites included in this study from Western Asia and North Africa. 1. el-Wad, 2. Kebara, 3. Hayonim, 4. Mallaha, 5. Wadi Halfa.

El Wad

El-Wad cave and terrace are situated on the south bank of Wadi el-Mughara, 44.5m above sea level on the western flank of Mount Carmel, 20 km south of Haifa (Fig. 7.4.1). The cave is comprised of two outer chambers (I & II), a corridor and four inner chambers (III-VI). Dorothy Garrod undertook major excavations at the site over five seasons between 1929 and 1933 (Garrod and Bate, 1937). Excavations were renewed on the terrace by Valla and Bar-Yosef between 1980 and 1981 (Valla *et al.*, 1986), and in chamber III by Weinstein-Evron (1994;1998) between 1988 and present.

These excavations revealed deposits dating to the Middle Palaeolithic, Upper Palaeolithic, Natufian and Bronze Age and were divided into seven layers (A-G) (Garrod and Bate, 1937). The Natufian layer, B, stretched across chambers I and II, as well as the entire terrace and divided into two units, B1 and B2 (Bar-Oz *et al.*, 2004). A

high number of hominin burials, a rich lithic assemblage, decorative items, bone tools, ground stone implements, ochre and a large non-human faunal assemblage were all found within this layer (Bar-Oz *et al.*, 2004; Garrod and Bate, 1937; Weinstein-Evron, 1994).

Dating

Three radiocarbon dates were produced from charcoal samples taken from layer B2 within the cave: $12,950 \pm 200$ BP, $12,620 \pm 160$ BP and $10,740 \pm 190$ BP. The earlier date places the layer within the Early Natufian, while the later dates place it in the Late Natufian (Weinstein-Evron, 1991). Radiocarbon dates of $11,920 \pm 660$ BP and $11,476 \pm 600$ BP were also retrieved from animal bone found within layer B2 on the terrace (Belfer-Cohen, 1988). These two sets of dates place the Natufian occupations of the site at the end of MIS 2.

Tool industries

Layer B was divided into two separate units on typological grounds, with B1 containing a Late Natufian industry and B2 containing an Early Natufian industry (Garrod and Bate, 1937). Both units displayed a high density of flint tools and debitage, concentrated on the terrace. The stone tools included arrowheads, lunates, triangles, points, blades, scrapers, microburins, sickle-blades, burins, borers, endscrapers, notched blades, picks, discs and retouched flakes (Garrod & Bate 1937). Layer B2 also contained an abundant bone tool industry, including points, harpoons, gorgets (collars), skin-rubbers, sickle-hafts, pendants and sculptured objects (Garrod & Bate 1937). Pierced teeth, shells, tablets with incisions, polishers, phallic objects and pestles and mortars were also found within the Natufian layer (Garrod & Bate 1937).

Non-human fauna

Layer B contained an abundant but highly fragmentary non-human faunal assemblage dominated by the remains of gazelle (*Gazella* sp.). It also included the remains of wild horse (*Equus caballus*), wild boar (*Sus scrofa*), bovid (*Bos* sp.), fallow deer (*Dama mesopotamica*), ibex (*Capra* sp.), wild ass (*Equus hemionus*), hare (*Lepus* sp.), badger (*Meles meles*) and carnivores such as hyaena (*Crocuta crocuta*), red fox (*Vulpes vulpes*), wild cat (*Felis silvestris*), domestic dog (*Canis familiaris*), leopard (*Panthera pardus*) and bear (*Ursus* sp.), as well as various rodent and reptile species (Garrod and Bate, 1937). Bar-Oz *et al.* (2004) highlighted an increase in the numbers of fallow deer and small game in layer B2, and a decrease in the number of gazelle.

Flora

Although plant remains were not retrieved from the deposits during Garrod's excavations, fifteen pollen samples were taken during Weinstein-Evron's more recent exploration of Cave III. Oak (*Quercus calliprinos*) and pistachio (*Pistacia* sp.), pine (*Pinus halepensis*) olive (*Olea europaea*), tamarisk (*Tamarix* sp.) and carob (*Ceratonia silqua*) trees. Hawthorn (*Crataegus* sp.), myrtle (*Myrtus* sp.), (*Cistus* sp.), (*Scabiosa* sp.), (*Fabaceae*) were well represented. Thirty-two pieces of charcoal were analysed and came from six woody species: (*Tamarix* sp.), 3x (*Quercus* sp.), (*Salix* sp.), (*Myrtus*).

Hominin remains

Sixty-two burials and 96 hominin skeletons were uncovered during the excavation of layer B (Bar-Oz *et al.*, 2004; Belfer-Cohen, 1995). Whilst most of the burials were found on the terrace, some were discovered within the cave and at its entrance (Garrod and Bate, 1937). The hominin remains varied in completeness from scattered fragments to complete skeletons, some of which were buried singly, some in groups. The skeletons buried within the cave and its entrance all lay in extended positions, while those on the terrace lay in a flexed position and some were decorated (Belfer-Cohen, 1995). The majority of the burials belonged to the Early Natufian (Garrod and Bate, 1937). Seventeen of these individuals have been included in the current study.

EW-226

This skull fragment included the left part of the maxillary palate, containing all of the left upper teeth apart from the third molar.

EW-232

Most of the upper palate was preserved in this skull fragment, containing the left third and second molars, the first molars, the fourth premolars and the right third premolar, canine and second incisor.

EW-233

This partial mandible contained the left molars and fourth premolar.

EW-234

The remains of this skeleton included a piece of the maxillary palate and an almost complete mandible. These contained the majority of the teeth, lacking only the upper right first incisor, the lower incisors, right third premolar and canine.

EW-253

This maxilla fragment and almost complete mandible lacked three upper incisors, the upper left third premolar and the right second and third molars, as well as the lower incisors, canines and three premolars.

EW-255

This piece of the maxillary palate lacked the incisors, right canine, third premolar and right second and third molars. It was associated with an almost complete mandible that lacked the incisors, left canine and third premolar, and right fourth premolar.

EW-260

The remains of this individual included a well-preserved skull and mandible with a complete dentition.

EW-261

This maxillary fragment included most of the upper palate and contained the third molars, the left second molar, the right first molar, the fourth premolars, the right third premolar and one incisor. The associated mandible lacked only three incisors.

EW-262

This maxillary palate only lacked two incisors, which appear to have been lost *ante-mortem* and may represent evidence of tooth ablation. The mandible contained the third molars, the left second molar, premolars, canines and incisors.

EW-265

This mandible contained a complete dentition.

EW-271

This maxillary fragment lacked the second incisors, the right canine and the third premolar, whilst the mandible lacked the third premolars.

EW-272

The remains of this individual included a well-preserved mandible, containing a complete dentition.

EW-273

This partial mandible contained the right molars, premolars and all the incisors.

EW-275

This maxillary fragment contained the right molars and premolars.

EW-276

This mandible only lacked the second incisors.

EW-287

This maxillary palate lacked the left molars and three incisors, and the associated partial mandible lacked the right third molar and two incisors.

EW-297

This maxillary palate contained the first and second molars, the fourth premolars and the right third premolar, canine and two incisors.

These individuals showed varying amounts of wear from slight to heavy. Evidence for tooth ablation was found within seven individuals from el-Wad (Smith, 1991b). Three upper incisors, for example, had been removed *ante-mortem* from EW-232, and the removal of three upper incisors from EW-262 meant all of the teeth were heavily worn, except for the lower incisors, as they lacked their upper counterparts. Other unusual patterns were noticed within this collection, such as the asymmetry of wear in the lower teeth of EW-255, with the right side being more heavily worn. Evidence of caries was found in 2.8% of individuals examined by Smith *et al.* (1984), and hypoplasia was seen in 15% of individuals.

Hayonim

Hayonim cave and terrace are located on the western bank of Wadi Izhar, a small tributary of Nahal Yassaf, in the western Galilee region of Israel, approximately 5 km northwest of the town of Carmel (Fig. 7.4.1). It is situated 250m above sea level and 13 km east of the Mediterranean coast. Bar-Yosef, Arensburg and Tchernov excavated the site between 1965 and 1979, uncovering 3.5m of hominin occupation layers, A-E, dating from the Middle Palaeolithic to the Neolithic (Arensburg *et al.*, 1990). More recent excavations between 1992 and 2000 exposed a further 6.5m of stratigraphic sequence from the Pleistocene (Rink *et al.*, 2004). Hominin remains were

discovered within layer B, associated with several dwelling structures, grave structures, rich flint and bone industries, ground stone utensils and various artistic manifestations, such as decorated and incised artefacts that represent the remains of a Natufian base camp (Bar-Yosef, 1991a; Bar-Yosef and Goren, 1973; Belfer-Cohen, 1988).

Dating

Two AMS radiocarbon dates, $12,360 \pm 160$ BP and $12,010 \pm 180$ BP, were retrieved from lupin seeds located within the lower levels of the Natufian deposits, placing them towards the end of MIS 2 (Hopf and Bar-Yosef, 1987).

Tool industries

Almost 6,000 stone tools and pieces of debitage were discovered within the Natufian layer at Hayonim. The most common tool types were burins, notches, denticulates, microliths, geometric microliths and retouched flakes (Bar-Yosef and Goren, 1973; Bar-Yosef and Tchernov, 1966). Borers, backed pieces, scrapers, blades, bladelets, sickle blades, truncations, bifacial tools and picks were present. The use of the micro-burin technique and Helwan retouch were also noted amongst this assemblage (Bar-Yosef and Goren, 1973).

Over 600 ground stone objects were discovered within layer B, including mortars, cup-holes, pestles, rubbing stones, mullers, hammerstones and various heavy duty scrapers (Bar-Yosef, 1991a). A rich bone tool assemblage dominated by points, and including awls, bi-points, large points, spatulae, hafts, polished horns and retouchers, was also present (Bar-Yosef, 1991a; Bar-Yosef and Goren, 1973; Bar-Yosef and Tchernov, 1966; Bar-Yosef and Valla, 1991). Bone was additionally used to make decorated and incised objects and pendants, and carnivore teeth were perforated (Bar-Yosef, 1991a; Bar-Yosef and Belfer-Cohen, 1999).

Non-human fauna

The remains of gazelle (*Gazella* sp.) dominated an abundant non-human faunal assemblage from layer B. Brown hare (*Lepus europaeus*) occurred in high numbers and the remains of fallow deer (*Dama mesopotamica*), bovid (*Bos* sp.), red deer (*Cervus elaphus*), badger (*Meles meles*), fox (*Vulpes vulpes*), rodents, reptiles and birds were also present. The complete remains of two dogs (*Canis familiaris*) were found within a Natufian burial, which also contained the remains of three hominin skeletons (Tchernov and Valla, 1997).

Marine molluscs were commonly found within layer B and were mostly represented by *Levantina caesareana* (Bar-Yosef and Tchemov, 1966). Many of these shells were charred and broken, suggesting that they provided a source of food for the site's inhabitants. Various types of dentalium shells were also found within the cave and appear to have been used as objects of personal ornamentation (Bar-Yosef and Tchemov, 1966).

Flora

Studies of the phytolith assemblages from the hearths and the associated sediments showed that wood ash was the major source of fuel during the Natufian. A high number of grasses were also preserved (Albert *et al.*, 2003).

Hominin remains

Sixteen graves containing 48 individuals were discovered within the Natufian layer at Hayonim, as well as a number of disarticulated remains scattered throughout the occupational layers (Belfer-Cohen, 1988). Most of the graves were located outside the living and working areas, in the inner parts of the cave, and contained multiple burials, both primary and secondary. These were often marked by limestone slabs or stone, and were paved with small stones (Belfer-Cohen, 1988). Nine individuals from this collection have been included in the current study.

H2

This adult female was discovered within grave I. The skeleton lay slightly on the right side in a recumbent position with the legs flexed and right hand folded and holding the left hand, both resting on the body. The skull lay on a pile of stones (Bar-Yosef and Goren, 1973). The maxilla and mandible contained an almost complete dentition, lacking only the upper left incisors. The bones of an adult male skeleton (H3) were found scattered above this skeleton.

H4

Grave III contained the skeleton of an adult male c.20-25 years old that lay on the left side in a partially contracted position with the skull resting on a stone (Bar-Yosef and Goren, 1973). The right hand lay across the chest and the left was situated between the legs. Several stone slabs covered the skeleton. The right part of the palate and its dentition were preserved, and the mandible, which was more complete, lacked only the right canine and premolars.

H7

Grave V, made almost entirely of stone slabs, contained secondary burials representing at least three individuals, including H7, the skeleton of an adult, probably male, aged between 35 and 40 years (Bar-Yosef and Goren, 1973). The body had been deposited in a prone position (on its chest), so that the right shoulder lay on top of the shoulder of H8 (Tchernov & Valla 1997). A heavy block of limestone had been placed on the chest of H7, and three gazelle horn cores were also associated with this skeleton; one deposited on the top of the right shoulder, one under the chest and another under the right arm. Many of the teeth had been lost from the mandible both ante- and *post-mortem*, and only the left second and first molar and fourth premolar remained.

H17

This skeleton of an adult male aged between 25 and 30 years was found in grave VIII, lying on its back in a semi-flexed position with the pelvis resting above the skeleton of H20 (Bar-Yosef and Goren, 1973). Many dentalium shells, probably the remains of a decorated garment, were found scattered near the arms (Belfer-Cohen, 1988). The maxilla lacked the third and second molars and the right first molar, and the mandible lacked the third molars and the left second molar.

H19

Grave VIII also contained the skeleton of an adult male aged between 20 and 25 years that lay side-by-side with H17 in a recumbent position, and on top of H27 and H20 (Bar-Yosef and Goren, 1973). The maxilla lacked the right third molar and three incisors, while the mandible contained a complete dentition.

H20

This skeleton of an adult male aged between 25 and 30 years was discovered in an extended position at the bottom of grave VIII, below H17 and H19 (Bar-Yosef and Goren, 1973). The maxilla contained the molars, right fourth premolar, left canine and three incisors, and the mandible lacked all of the right teeth except for the first incisor.

H25

Grave IX contained the skeleton of an adult male of 25-30 years that had been buried in a flexed position on its right side, lying directly above H27 (Bar-Yosef and Goren, 1973; Belfer-Cohen, 1988). The arms were folded across the chest, and one was adorned with a bracelet of 20 partridge tibia-tarsus beads (Belfer-Cohen, 1988). The

maxilla lacked three incisors and the left canine, whilst the lower incisors, left canine and first molar were missing from the mandible.

H26

This upper skeleton of a young adult female, aged between 18 and 20 years, was also found at the bottom of grave VIII (Bar-Yosef and Goren, 1973). It lay in a recumbent position with the skull facing west. The mandible lacked the third molars, left third premolar, the canines and two incisors.

H27

Grave IX also contained the skeleton of an adult male of 25-30 years that had been buried in a flexed position with the legs resting upon H26 (Bar-Yosef and Goren, 1973). The maxilla lacked the left second and third molars. The right third molar and the incisors and canines were missing from the mandible.

These skeletons possessed varying amounts of tooth wear, probably representing their mixed ages. The size of the third molar is less than that of any other Natufian site (Smith, 1991b) and has been associated with a high frequency of the congenital absence of the third molar (Smith, 1973). Hypoplasia was found in 10% of individuals, and caries was only found in two individuals (Smith *et al.*, 1984; Smith, 1991b).

Kebara

Kebara cave is located on the western escarpment of Mount Carmel, 65m above sea level, overlooking the Mediterranean coastal plain (Fig. 7.4.1). Turville-Petre (1932) was the first to excavate the site in 1931, removing the entire Natufian sequence. Later excavations also uncovered deposits from the Middle Palaeolithic, including two Neanderthal skeletons (section 7.2), Aurignacian and Kebaran. The Natufian layer contained a rich lithic industry, numerous bone objects, mortars and pestles, and a mass burial pit near the entrance to the cave (Bocquentin and Bar-Yosef, 2004).

Dating

The hominin remains from the mass burial pit were radiocarbon dated to $11,150 \pm 400$ BP (Bocquentin & Bar-Yosef 2004), and the charred remains discovered within the cave to $12,470 \pm 180$ BP (Hedges *et al.* 1993; Bar-Yosef & Sillen 1993). Both these dates place the Natufian occupation of the cave at the end of MIS 2.

Tool industries

The tool industry from the Natufian deposits has never been formally described but included a large number of stone sickle blades, lunates, pestles and mortars as well as numerous bone objects (Bocquentin and Bar-Yosef, 2004).

Non-human fauna

The remains of gazelle (*Gazella* sp.) dominated the non-human faunal assemblage from the Natufian deposit at Kebara; most of these remains came from adult males, suggesting some form of prey selection and herd management (Saxon, 1974). The remains of aurochs (*Bos primigenius*), hartebeest (*Alcelaphus buselaphus*) and wild boar (*Sus scrofa*) were numerous, and the assemblage also included fallow deer (*Dama mesopotamica*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), horse (*Equus* sp.), red fox (*Vulpes vulpes*), wolf (*Canis lupus*), brown bear (*Ursus arctos*), marten (*Martes* sp.), polecat (*Vormela peregusna*), badger (*Meles meles*), hyaena (*Crocota crocuta*), wild cat (*Felis silvestris*) and hare (*Lepus* sp.) (Saxon, 1974). Microfauna was rare and Saxon (1974) suggested this was due to the lack of sieving of the deposits during Turville-Petre's excavations.

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

Although the burial context of the mass grave has never been formally described, the completeness of the skeletons suggested they were all primary burials (Bocquentin & Bar-Yosef 2004). Seventeen individuals, including 11 children and six adult males, appeared to have been buried in quick succession without any attempt at orientation and were packed with stones (Bocquentin & Bar-Yosef 2004). A series of charred hominin remains were also found within the Natufian layers at the rear of the cave (Turville-Petre 1932). Five individuals have been included in the current study.

H2

The remains of this adult included a partial maxilla and a mandible that contained the upper first molars, left second molar, fourth premolar, and lower left first and second molars.

H3

The maxilla and mandible belonging to this adult skeleton retained an almost complete dentition, lacking only the upper right incisors.

H4

This incomplete skeleton of a mature adult male included parts of the maxilla and mandible, containing the upper right molars, premolars and canine and the lower right molars, premolars and three incisors. A stone projectile was discovered embedded in the seventh or eighth thoracic vertebra and may represent the cause of death (Bocquentin and Bar-Yosef, 2004).

H8

The remains of this adult skeleton included a maxilla and a mandible that only lacked the upper incisors, three lower incisors and the lower left canine and third premolar.

N357

This piece of maxilla contained all of the upper left teeth apart from the second incisor.

These individuals all possessed slight to moderate amounts of wear. Evidence of tooth ablation was found on one of the individuals by Smith (1991b). Evidence of caries was found in only 0.5% of individuals, whilst hypoplasia was present in 23% of individuals examined by Smith *et al.* (1984).

Mallaha (Eynan)

Mallaha is a large open-air site located on the western shore of the ancient lake of Houleh in the Jordan valley, Israel (Fig. 7.4.1). It is situated approximately 72m above sea level, near the ancient spring of Aïn Mallaha. Perrot (1966) first excavated the site between 1955 and 1961, followed by Lechevallier between 1974 and 1976 (Lechevallier and Valla, 1974) and more recently by Valla and colleagues between 1996 and present (Valla *et al.*, 1999;2004). These excavations revealed 2-3m of deposits that spanned the entire Natufian period (Perrot and Ladiray, 1988). These were sub-divided into four stratigraphic levels, each of which contained structures, pits, hearths, hominin burials, an abundant bone and stone industry and non-human fauna (Perrot, 1966).

Dating

Stratigraphic and archaeological observations suggest a more or less continuous occupation of the site during the Natufian period (Perrot and Ladiray, 1988). Radiocarbon dates from other Natufian sites suggests that Mallaha was occupied from 12,500 BP until 10,300 BP.

Tool industries

The tool industry from Mallaha was largely homogenous with few differences in typologies throughout the Natufian period (Valla, 1984). It was dominated by flakes, retouched blades and racloirs, and also contained burins, microliths, borers, blades and bladelets, and massive scrapers (Cauvin, 1966; Valla, 1984). A notable feature of the stone tool assemblage was the rarity of geometric microliths, common in other Natufian sites (Cauvin, 1966). Bone tools also formed an important part of the tool industry. These were dominated by points and included needles, hooks, spatulas and sickles (Perrot, 1966; Stordeur, 1988). The assemblage also contained a high number of portable stone objects such as vases, bowls, pestles, mortars, millstones, perforated and incised rocks, as well as small figurines (Perrot, 1966). Objects of personal ornamentation were found throughout the Natufian layers, including perforated gazelle phalanges, bones, teeth and shells (Perrot, 1966).

Flora

The remains of fruits and seeds, such as *Pistacia* and *Amygdalus* were found within the Natufian deposits, and the presence of pestles, mortars and other grinding tools at the site strongly suggest that plant materials were being processed (Horowitz, 1971; 1975).

Non-human fauna

The Natufian levels contained a homogenous non-human faunal assemblage dominated by the remains of gazelle (*Gazella* sp.) (Bouchud, 1987). It also included ass (*Equus asinus*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), fallow deer (*Dama mesopotamica*), aurochs (*Bos primigenius*), hartebeest (*Alcelaphus buselaphus*), wild goat (*Capra aegagrus*), wild boar (*Sus scrofa*) and the remains of carnivores such as wolf (*Canis lupus*), fox (*Vulpes* sp.) and wild cat (*Felis silvestris*), as well as rodents and insectivores. The high numbers of tortoise (*Testudo graeca*), brown hare (*Lepus europaeus*), fresh water fish, shellfish and birds found suggested that they all made an important contribution to the diet of the site's inhabitants

(Bouchud, 1987). All parts of the skeleton (except in the case of bovids) were represented, strongly suggesting that whole animals were brought to the site.

Hominin remains

A total of 105 burials were discovered at the site within cemeteries and habitation structures, including isolated and multiple, primary and secondary, and decorated and un-decorated burials (Perrot, 1966). They have been associated with the early, middle and recent Natufian layers and 18 of these individuals have been included in the current study.

Early Natufian

H16

This partial skeleton of an adult male had been placed on its back with the head facing northeast and the legs bent (Perrot and Ladiray, 1988). It included part of the maxilla, containing the molars and the premolars.

H18

The remains of this individual were deposited under the arm of H19 (Perrot and Ladiray, 1988). The cranium, which is thought to represent the remains of an adult male, had been turned upside down and included a complete dentition.

H87

This skeleton of an adult male lay on its right side in a crouched position with the hands close to the face and the knees close to the chin (Perrot and Ladiray, 1988). It included a fragment of maxilla, containing the right first and second molar, premolars canine, and two incisors, and a mandible lacking only the right fourth premolar. A bracelet of pierced shells was found on each arm (Perrot and Ladiray, 1988).

H91

This almost complete, yet badly preserved, skeleton of an adult female had been placed on its back with the legs flexed towards the right side (Perrot and Ladiray, 1988). The mandible was almost complete, missing only the left incisors. It included a high number of personal decorations including a collection of pierced teeth, representing a possible head-dress, the remains of a necklace, two bracelets, a belt, a bone axe and bone tools (Perrot and Ladiray, 1988).

H93

This partially destroyed skeleton of an adult, probably female, aged between 40 and 45 years old lay on its right side in a contracted position (Perrot and Ladiray, 1988). The mandible was almost complete, lacking only the first molars and one incisor.

Middle Natufian burials

H37

The remains of this adult male aged between 45 and 50 years old were discovered within a habitation structure, with the skull facing towards its centre (Perrot, 1966). The complete cranium and mandible appear to have formed a secondary burial. The mandible contained a complete dentition, however, the maxilla lacked the second molars, the left first molar, the right third premolar, the left canine and three incisors.

H70

This burial contained the fragmentary skeleton of an adult of indeterminate sex that lay on its right side in a flexed position with the hands in front of the face (Perrot and Ladiray, 1988). The maxilla included the left dentition, except for the third molar, while the mandible was missing only the left second and third molars.

H80

This almost complete skeleton of an adult male, aged between 25 and 30 years old, lay on its right side in a flexed position with the legs and arms folded and hands in front of the face (Perrot and Ladiray, 1988). The maxilla lacked three incisors, and the right third molar, whilst three incisors were missing from the mandible.

Recent Natufian

H34

This skeleton of an adult, probably male, aged c. 25 years old was discovered directly above H35 (Perrot and Ladiray, 1988). It lay in a seated position with the legs bent and arms by the side of the face, with the head resting on the thorax. The maxilla lacked three incisors, and the mandible's dentition was complete.

H52

The remains of this individual were found dispersed throughout a burial pit and represented the skeleton of an adult female c. 25 years old (Perrot and Ladiray, 1988). They included the maxilla and the mandible, which lacked only one upper right incisor.

Final Natufian

H101

This skeleton of an adult female lay on its back with the legs folded towards the left side (Perrot and Ladiray, 1988). It included a mandible that lacked three incisors.

General Natufian

H66

This skull and mandible lacked the upper right incisors and third premolar and the lower incisors, the right canine, premolars and first molar.

H69

This skull and associated mandible were discovered within an oblong-shaped pit, containing three other individuals, representing a secondary burial (Perrot and Ladiray, 1988). The dentition lacked three upper incisors and the lower right incisors and canine.

H71

The cranial and post-cranial fragments of this adult female c.50 years old were discovered within the same oblong-shaped pit as H69 (Perrot and Ladiray, 1988). They included a mandible, lacking the left first molar and the right second incisor and a maxilla containing the upper right molars and fourth premolar.

H154

This maxilla and mandible lacked the upper right third molar, second molars, canines and three incisors, and two lower incisors and the lower right canine.

H156

This complete maxilla and mandible lacked the upper right third and second molars, the left first molar and the right first incisor.

H157

This maxilla lacked the right molars and the left third and second molars. The mandible only contained the molars and the left fourth premolar.

H168

This mandible lacked the left third molar and fourth premolar.

These individuals showed varying amounts of tooth wear from slight to heavy. *Ante-mortem* tooth loss was present in several individuals, such as H90, and Smith (1991b) identified evidence for tooth ablation in three individuals from the site. Caries was found in 2.8% of individuals examined by Smith *et al.* (1984), and hypoplasia in 27%.

Wadi Halfa

The open-air site of Wadi Halfa is situated 155m above sea level near to the modern village of the same name, 2.5 km from the River Nile and within the Beni-Segoul region of Sudan (Fig. 7.4.1). Armelagos, Ewing, Green and Saxe excavated the site between 1963 and 1964, uncovering hearth deposits and a large number of burials (Greene and Armelagos, 1972).

Dating

The excavators were unable to obtain reliable radiocarbon dates from the deposits, due to permineralization of the organic remains (Greene and Armelagos, 1972). The presence of a Qadan-like tool industry at Wadi Halfa, which has been radiocarbon dated to between 13,900 and 8350 BP (Wendorf, 1965), provided a date range for the site.

Tool industries

The Qadan-like stone tool industry from Wadi Halfa was dominated by uniface flint points and scrapers (Wendorf, 1965). Sandstone mullers or manos, crescent flakes, geometric microliths, side-scrapers, borers, burins and notched flakes, as well as ostrich eggshell beads were also present.

Non-human fauna

The non-human faunal assemblage included large bovids (*Bos* sp.), fish, birds, reptiles and shellfish (Wendorf, 1965), but has never been formally described.

Flora

While there are no published plant remains from this site, the gathering and utilisation of wild grass seeds was indicated by the presence of a large number of grinding stones (Greene and Armelagos, 1972).

Hominin remains

Thirty-six skeletons, most fragmentary, were recovered from the Late Epipalaeolithic deposits at Wadi Halfa and described by Greene and Armelagos (1972). The majority

of the burials were single or double, but one area contained a mass burial pit. Nine hominin skeletons have been included in the current study.

Burial 15

This burial contained the fragmentary skeleton of a young adult female, including an almost complete mandible. Its third molars were partially erupted and the left canine was missing.

Burial 20

The fragmentary skeleton of this adult, probably female, included a skull and mandible. Some of the dentition appears to have been lost *ante-mortem*, probably through wear. The lower right second molar, premolars and canine, and the upper right second molar, three incisors, the left canine and premolars were still present. The mandibular condyle showed asymmetrical development (the right being much larger than the left), causing an asymmetrical tooth wear pattern.

Burial 24

This almost complete skeleton of an adult male included a maxilla and a mandible. The lower dentition was complete, but several teeth appear to have been broken *post-mortem*.

Burial 25

This burial contained the complete skeleton of an adult female, lacking the upper left second incisor and canine and the lower fourth premolar. A lump of bone was discovered along the sagittal suture of the skull, indicative of a calcified traumatic haematoma, possibly caused by a large blow.

Burial 28

The fragmentary skeleton of this adult, probably female, included a fragment of maxilla, containing the left molars, third premolar and canine, and an almost complete mandible, lacking three incisors and the right canine. All of these teeth appear to have been lost *ante-mortem*.

Burial 31

This burial contained the skeleton of an adult male with a partial mandible, preserving the molars and the right fourth premolar.

Burial 32

The almost complete skeleton of an adult female included a skull and mandible. Only part of the maxilla was preserved, containing the upper right molars, premolars, canine and second incisor. The mandible was relatively complete, lacking only the left fourth premolar.

Burial 34

This burial contained the almost complete skeleton of a mature adult female. Only the upper right first molar, lower third premolar and a lower incisor were missing from its dentition.

Burial 37

This almost complete skeleton of an adult male, showed an interesting number of pathologies, such as a parry fracture in the left ulna, a well-aligned fracture of the left fibula and metatarsal and the osteoarthritic lipping of three thoracic vertebra. It lacked the upper right third premolar canine and incisors, as well as the lower right first molar and the left incisors.

Few of the skeletons from Wadi Halfa retained their incisors, due to *post-mortem* loss, but those that could be observed showed some evidence for shovelling (Greene *et al.*, 1972). Alveolar abscessing around the roots of one or more teeth was observed in eight skeletons. Only four out of 397 teeth observed by Greene *et al.* (1972) showed evidence for caries and 24 of the adults showed some signs of alveolar recession, which can probably be attributed to the heavy amounts of tooth wear observed in so many of the adults from Wadi Halfa.

7.5 Mesolithic Modern Humans



Figure 7.5.1: Mesolithic Modern Human sites included in this study from Europe. 1.Dragsholm, 2.Korsør Nor, 3.Melby, 4.Vedbæk, 5.Baume de Montclus, 6.Gramat, 7.Rochereil, 8.Téviec, 9.Cabeço da Arruda, 10.Moita do Sebastião.

Dragsholm

Dragsholm is a burial site located in Zealand, Denmark (Fig. 7.5.1). Thorvildsen and Becker first excavated the site between 1938 and 1939, uncovering two cist graves within a Neolithic tumulus (Bröste *et al.*, 1956). Subsequent excavations undertaken in the early 1970s by Brinch Petersen (1973;1974) further revealed a Mesolithic double burial and single Neolithic burial.

Dating

The Mesolithic double grave was radiocarbon dated to $5,160 \pm 100$ BP within the late Ertebølle time frame (Tauber, 1973).

Tool industries

Several tools were found within the Mesolithic grave, many of which probably represented intentional grave goods (Brinch Petersen, 1974). They included a bone awl, a transverse arrowhead and a flat bone dagger with ornaments drilled in a geometrical pattern on both faces. The burial also contained 144 pierced animal teeth (Brinch Petersen, 1974).

Non-human fauna

The pierced animal teeth found within the grave mostly came from red deer (*Cervus elaphus*), but also from auroch (*Bos primigenius*) and elk (*Alces alces*) (Brinch Petersen, 1974).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The Mesolithic double grave contained the skeletons of two females lying side-by-side, Dragsholm A and B. A large amount of red ochre surrounded these skeletons and both have been included in the current study.

Dragsholm A

This skeleton of a mature adult female, aged between 40 and 50 years old, lay in an extended supine position (Brinch Petersen, 1973). It included a maxilla and mandible, containing an almost complete yet heavily worn dentition that lacked only the upper right first and second molar, and the lower left premolars. Strings of tooth pendants were found around the pelvis, as well as on the chest and on the upper right arm.

Dragsholm B

The skeleton of this young adult female, c. 18 years old, lay in a supine position next to the skeleton of Dragsholm A, with the legs slightly flexed (Brinch Petersen, 1973). The left third molar and the right first and second molars were missing from the maxilla, while the partial mandible only contained the left teeth. A flat bone dagger and the remains of a string of tooth pendants were found near the pelvis.

Korsør Nor

The site of Korsør Nor is located within the modern harbour of the same name on the western coast of Sjaelland, within the Zealand region of Denmark (Fig. 7.5.1). It was discovered 2.5–4m below sea level during the extension of the harbour in the 1940s. Workmen collected a limited number of the finds from this Mesolithic settlement, while Jensen and Norling-Christensen excavated a single grave. Unfortunately no record was made of the cultural layers, but evidence for longboats and stationary fishing structures were found (Schilling, 1997).

Dating

The hominin remains from Korsør Nor 1 have been radiocarbon dated to between 7350 and 6850 BP (Schilling, 1997).

Tool industries

The hominin skeletons were associated with a small flint assemblage, including scrapers, axes and a pointed flake (Schilling, 1997). A number of artefacts made from bone and antler, such as axes and slotted bone daggers characteristic of the Ertebølle culture, were also discovered in the area surrounding the burial (Bröste *et al.*, 1956).

Non-human fauna

While the burial was not associated with any non-human faunal remains, stable isotope analysis of the skeletal remains suggested that 75% of their dietary protein came from the sea, possibly supplemented by game, nuts and berries (Bennike, 1997; Schilling, 1997).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

A double burial as well as a number of scattered, disarticulated hominin bones were discovered at Korsør Nor, representing at least seven individuals; two children and five adults. The two skeletons from the double burial have been included in the current study.

Korsør Nor 1

This skeleton of an adult male, 30-50 years old, was discovered within a wooden structure in an extended supine position (Bennike 1997). Evidence for two major, healed lesions were observed on the skull that contained two heavily worn teeth; the upper right first molar and third premolar (Schilling, 1997). A large flint blade and knife were discovered near the legs (Newell *et al.*, 1979).

Korsør Nor 2

This disarticulated and partial mandible was discovered within the occupational debris from Korsør Nor. It contained the heavily worn lower left first and second molars, premolars and canine and second incisor. A large, chronic abscess was noted by Bennike (1997) at the root of the lower left second molar.

Melby

This Mesolithic burial was discovered in 1969 on the bank of a prehistoric inlet, the Melby Enghave, in northern Zealand, Denmark (Fig. 7.5.1). Originally the subject of amateur excavations it was fully excavated by Lund-Hansen.

Dating

The hominin skeleton found within the burial was radiocarbon dated to 5,830 ± 110 BP (Tauber, 1970), assigning this individual to the Ertebølle culture.

Tool industries

Two round-butt axes, characteristic of the Maglemose, Kongemose and Ertebølle cultures, were discovered within the burial (Hansen *et al.*, 1972).

Non-human fauna

It was not possible to find published information on animal remains from this site.

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

Melby

This burial contained the skeleton of an adult male, 35-50 years old, lying in an extended supine position (Hansen *et al.*, 1972). The skull and mandible contained the

upper right third molar, the second and first molars and the fourth premolars, as well as the lower first and second molars, the fourth premolars and the left third premolar. These teeth were all heavily worn and possessed evidence of enamel hypoplasia and enamel chipping of the anterior teeth (Hansen *et al.*, 1972). Evidence of arthritis was found within several parts of the skeleton, including the mandible, cervical vertebrae and the bones forming the elbow joint.

Vedbæk

Vedbæk is a collection of open-air sites located on a former island within the bay of the Littorina Sea, on the eastern coast of Sjaelland, 15 km north of Copenhagen, Denmark (Fig. 7.5.1). Mathiassen excavated Vedbæk Boldbaner between 1944 and 1945, discovering two single graves, an inhumation and a cremation. Brinch Petersen undertook major excavations at the neighbouring site of Vedbæk Bøgebakken in 1975, uncovering a cemetery comprising 17 graves.

Dating

Three skeletons from the cemetery at Vedbæk Bøgebakken produced radiocarbon dates of $6,050 \pm 75$ BP, $6,290 \pm 75$ BP and $5,810 \pm 105$ BP (Albrethsen and Brinch Petersen, 1976). The site of Vedbæk Boldbaner has been radiocarbon dated to $6,510 \pm 110$ BP (Tauber, 1970). The dates from both sites agree with the evidence from the tool industries, placing them within the Early Ertebølle period.

Tool industries

Both Vedbæk sites contained a tool industry of Early Ertebølle type, dominated by microlithic tools (Petersen, 1984). They also contained a large number of polished axes, transverse arrowheads, rhombic points, core-axes and blades, as well as low numbers of burins, borers and scrapers (Albrethsen and Brinch Petersen, 1976; Petersen, 1984). The bone and antler industry included axes, harpoons, slotted bone points, spatulas, beads, and pierced teeth from elk and aurochs. Perforated snail shells were also discovered within some of the graves.

Non-human fauna

The remains of fish dominated the non-human faunal assemblages from the sites of Vedbæk. The remains of hedgehog (*Erinaceus europaeus*), beaver (*Castor fiber*), pine marten (*Martes martes*), wild cat (*Felis silvestris*), grey seal (*Halichoerus grypus*), wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), porpoise

(*Phocoena phocoena*) and several species of bird were also present (Albrethsen and Brinch Petersen, 1976; Oakley *et al.*, 1971). Stable isotope analysis of the hominin skeletons from Vedbæk also suggested that marine resources, such as shell fish or fish, were the main sources of protein for these individuals (Richards *et al.*, 2003).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

Twenty-three skeletons were discovered within 17 graves at Vedbæk Bøgebakken and two within graves at Vedbæk Boldbaner. Those from Vedbæk Bøgebakken were all located near to the habitation site and appear to have been deliberately laid out in parallel rows. Two individuals from Vedbæk Bøgebakken and one from Vedbæk Boldbaner have been included in the current study.

Vedbæk Bøgebakken 5

This grave contained the skeleton of an adult male, lying in an extended supine position surrounded by red ochre and with a flint blade resting on its pelvis (Albrethsen and Brinch Petersen, 1976). All of the upper teeth were present within the skull and only the right premolars were missing from the mandible.

Vedbæk Bøgebakken 15

The skeleton of this adult female and newborn baby were discovered within a heavily disturbed double grave (Albrethsen and Brinch Petersen, 1976). The skull of the adult female lacked the upper right incisors and the lower incisors were missing from the mandible. The upper incisors appear to have been lost *ante-mortem*, probably through wear.

Vedbæk Boldbaner A

This skeleton of a mature adult male, aged between 40 and 60 years, lay in an extended supine position, with four stones placed over the upper part of the skeleton. The maxilla lacked three incisors and the lower dentition was complete.

The population from Vedbæk had been noted for unusually heavy amounts of tooth wear, with dentine exposed even in the front teeth of 10-year-old skeletons (Albrethsen and Brinch Petersen, 1976). Evidence of dental chipping was noted along the outer

surfaces of the teeth and has been attributed to the mastication of hard food stuffs or the use of teeth as tools (Albrethsen and Brinch Petersen, 1976).

Baume de Montclus

Baume de Montclus rockshelter is located within the valley of the Cèze River, 3 km from the modern town of Montclus (Fig. 7.5.1). It is situated on the left bank of the river, 80 km from the coast and within the Gard region of France. Escalon de Fonton (1956) excavated the site between 1954 and 1969, uncovering 32 layers from three cultural periods; the Montclusian (16-32), Castelnovian (5-16), and Cardinal Neolithic (1-4). A single hominin burial was found towards the top of the Castelnovian deposits within layer 5.

Dating

Layer 4, directly above the hominin burial, was radiocarbon dated to 6640 ± 55 BP, 6300 ± 140 BP and $6,140 \pm 140$ BP. Layer 8, below the burial, was radiocarbon dated to $6,230 \pm 150$ BP (Escalon de Fonton, 1966; Newell *et al.*, 1979). Both these dates place these remains firmly within MIS 1.

Tool industries

The Castelnovian tool industry from Baume de Monclus was dominated by microliths, such as trapezoids, triangles and microburins, which Escalon de Fonton (1956) believed once formed harpoon armatures, and included borers and retouched arrowheads. It shared some of its tools types with the preceding Montclusian, such as scrapers, retouched flakes and Montbani bladelets (Darmedru and Onoradini, 2003). Additionally, layer 5 contained denticulated and retouched blades and bladelets, as well as several transverse points (Newell *et al.*, 1979). Shells were also used as tools.

Non-human fauna

Fish remains dominated the non-human faunal assemblage from the Mesolithic layers at Baume de Montclus. The remains of wild boar (*Sus scrofa*), red deer (*Cervus elaphus*) and a high number of fresh water shells (*Columbella rustica*), many of which had been burnt and pierced, were also present (Darmedru and Onoradini, 2003). The high number of fish remains combined with the dominance of microliths in the tools assemblage, suggest that fishing was an important activity at the site (Escalon de Fonton, 1956).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

Baume de Montclus 1

This almost complete skeleton of an adult female was discovered lying on its right side in a contracted position with the legs flexed and the hands close to the face (Ferembach, 1974; Vallois and de Félice, 1977). The suture closure, the stage of dental development and the light tooth wear indicated an age of between 18 and 20 years (Ferembach, 1974). The maxilla lacked the left third molar and the right third premolar, while the mandible contained a complete dentition.

Gramat

Gramat cave and rockshelter are located within a limestone plateau, 4 km from the town of Cuzoul within the Gard region of France (Fig. 7.5.1). Niederlender and Lacam (1933) excavated the site between 1923 and 1933, revealing seven layers of deposits (I-VII), dating from the Sauveterrian to the Neolithic. Hominin remains were discovered within levels II, IV and VI, all associated with a Tardenoisian tool industry and an abundant non-human faunal assemblage.

Dating

The site was dated using its stratigraphic association with the contemporary and neighbouring site of Rouffignac. Level C3 at this site was radiocarbon dated to 8370 ± 50 BP, the equivalent of layer II at Gramat (Newell *et al.*, 1979).

Tool industries

The Tardenoisian industry, associated with the hominin remains, was dominated by blades and included a high number of scrapers, microburins and points (triangular and Tardenoisian) (Lacam *et al.*, 1944). It also contained core scrapers, triangles, trapezoids, Montbani blades, as well as numerous discarded stone fragments and debitage. The bone tools included borers, lissoirs, awls, and an axe, with pierced animal teeth and bones also present.

Non-human fauna

The remains of roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*) dominated the non-human faunal assemblage from the Mesolithic

layers (Lacam *et al.*, 1944). It also included the remains wild horse (*Equus caballus*), large bovid (*Bos* sp.), fox (*Vulpes vulpes*), wolf (*Canis lupus*), wild cat (*Felis silvestris*), marten (*Martes* sp.), badger (*Meles meles*), hare (*Lepus* sp.) and vole (*Arvicola amphibius*).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

While the hominins discovered within layers IV and VI were represented by small isolated fragments, layer II contained a complete skeleton (Gramat 1), two partial mandibles (Gramat 2 and 3) and number of cranial fragments (Lacam *et al.*, 1944). Some of the cranial fragments bore cut marks which the excavators attributed to the action of stone tools. Gramat 1 and 2 have been included in the current study.

Gramat 1

This skeleton of an adult male, aged between 20 and 30 years, was discovered within a burial, lying on a large slab of limestone in an extended supine position (Vallois, 1944; Vallois and de Félice, 1977). The skull and mandible contained a well-preserved and moderately worn dentition, lacking two upper and one lower incisor. Five pierced seashells were discovered near the skull and a crude bone awl beneath the right hand (Vallois, 1944).

Gramat 2

This partial mandible of an adult, probably female, was discovered in close proximity to the Gramat 1 burial (Vallois, 1944). It contained four moderately worn teeth: the lower left molars and third premolar.

Rochereil

Rochereil cave and terrace are situated on the right bank of the River Dronne near the town of Grand-Brassac, within the Dordogne region of France (Fig. 7.5.1). Jude (1960) excavated the site between 1937 and 1939, discovering four levels of deposits and the partial remains four hominin skeletons. These remains were located within levels II and III, associated with artefacts from the Magdalenian and the Mesolithic (Azilien), respectively.

Dating

The hominin remains were dated using their associated cultural material to the Magdalenian (level II) and the Azilien (level III) (Jude, 1960).

Tool industries

Points and scrapers dominated the lithic industry from the Azilien level (3), with blades and burins also common, all made from locally acquired flint (Jude, 1960). The bone and antler industry was sparse, containing only four harpoons made from deer antler, two bone awls, and fragments of a spear and sticks. Objects of personal ornaments, such as beads and pendants, were also rare.

Non-human fauna

The assemblages from levels II and III were combined and therefore contained a mixture of cold and warm non-human fauna, including the remains of reindeer (*Rangifer tarandus*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), horse (*Equus* sp.), bison (*Bison priscus*), elk (*Alces alces*), ibex (*Capra ibex*), chamois (*Rupicapra rupicapra*), wild boar (*Sus scrofa*), wolf (*Canis lupus*), red fox (*Vulpes vulpes*), lynx (*Lynx lynx*), wild cat (*Felis silvestris*) and rabbit (*Oryctolagus cuniculus*), as well as fish, birds and shellfish (*Citellus superciliosus*) (Jude, 1960).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

The remains of one adult, two adolescents and one juvenile were discovered at the site. The burial of the adult skeleton, known as Rochereil 1, was found within level III of the cave and has been included in the current study.

Rochereil 1

This almost complete skeleton of an adult male, aged between 50 and 60 years, lay on its right side in tightly flexed position (Vallois and de Félice, 1977). It was covered and surrounded by heaps of ash, burnt earth and burnt flint (Jude, 1960). The skull and mandible contained an almost complete dentition, lacking only the upper right third molar, an upper incisor and the lower left third molar. All of the remaining teeth showed evidence of heavy wear and three had been affected by dental caries (Vallois and de Félice, 1977).

Téviec

The small island of Téviec, once part of the mainland, is now located 800m from the peninsula of Quiberon and 1.8 km from the coast of Brittany, France (Fig. 7.5.1). A shell midden, between 0.6 and 1m thick, was discovered on its north-western shore and Péquart and Péquart (1929) excavated the site between 1928 and 1930, discovering rich deposits that contained abundant hearths, non-human fauna, tools and burials (Péquart *et al.*, 1937).

Dating

Téviec was originally dated c. 6575 ± 350 BP using its cultural similarity to radiocarbon dated deposits at the neighbouring site of Hoëdic (Newell *et al.*, 1979). More recently, three bone samples from individuals found with grave K were radiocarbon dated to between 6510 and 6440 BP (Schulting and Richards, 2001).

Tool industries

The lithic industry from Téviec was dominated by microlithic tools such as, triangles, trapezoids and micro-burins, and included notches, semi-lunates, amygdaloid points, various points, blades, borers, awls, denticulates, burins and scrapers (Péquart *et al.*, 1937). Pestles, mortars, lissoirs and polishing stones were fashioned from pebbles of shale, quartz, granulite and sandstone. The bone and antler tool industry was relatively small, containing daggers, points, pins, batons, picks or clubs and amulettes. Pierced teeth, phalanges, shells and stone pebbles appeared to have been fashioned into necklaces, bracelets and headdresses. This Mesolithic tool industry was characteristic of the Tardenoisian (Vallois and de Félice, 1977).

Non-human fauna

An abundant, but fragmentary and often burnt, non-human faunal assemblage was discovered at Téviec. It was dominated by the remains of molluscs and shell fish, including mussel (*Mytilus edulis*), cockle (*Cardium edule*), winkle (*Littorina littorea*), limpet (*Patella vulgata*) and oyster (*Ostrea edulis*) (Péquart *et al.*, 1937). The mammalian assemblage was dominated by the remains of wild boar (*Sus scrofa*) and red deer (*Cervus elaphus*) and included roe deer (*Capreolus capreolus*), beaver (*Castor fiber*), hedgehog (*Erinaceus europaeus*), fox (*Vulpes* sp.), marten (*Martes* sp.), wild cat (*Felis silvestris*), bovid (*Bos* sp.), sheep/goat (*Ovis/Capra*), and domestic dog (*Canis familiaris*), as well as a high number of birds and fish (Péquart *et al.*,

1937;Schulting, 1996). Stable isotope analysis of the hominin skeletons from Tévéc supported these findings, suggesting a mixed marine and terrestrial diet (Richards and Hedges, 1999).

Flora

The analysis of hearth charcoals, revealed the presence of oak (*Quercus*), Bourdaine (*Rhamnus frangula*) and pear (*Pirus*) trees, probably used as fuel, and a high number of charred fruits, such as pears, and hazelnut shells (Péquart *et al.*, 1937).

Hominin remains

Twenty-three skeletons were discovered within ten graves at Tévéc, including seven males and eight females (Vallois and de Félice, 1977). Most of these skeletons were buried between the natural ground and the midden with hearths often found directly above them, containing one or two mandibles of red deer and/or wild boar (Schulting, 1996). Seven of these individuals have been included in the current study, five of which were found within a mass grave (Tévéc 7, 8, 9, 10 and 16), and all possessed heavy tooth wear.

Tévéc 1

This adult female skeleton, aged between 20 and 25 years, lay in a seated position with the lower legs flexed and the skeleton of a 2 month old baby held within the arms. A healed break was observed in the right radius (Boule and Vallois, 1937). The third molar, the second molar and incisors were missing from the maxilla and the mandible lacked one incisor and the right first molar. A tent-like structure made from red deer antlers was found directly above the skull and other grave goods included a decorated stylet, bone points, flint blades and perforated shells.

Tévéc 7

This skeleton of an adult male, aged between 35 and 47 years, lay in a supine position next to Tévéc 8 and 9 (Péquart *et al.*, 1937). Some osteo-arthritic lesions were observed in the shoulder joints and hands (Boule and Vallois, 1937). Most of the upper and all of the lower teeth appear to have been lost *ante-mortem*, with almost total resorption of the tooth sockets. Only the upper second and third molars and the right first molar were still present.

Téviec 8

Téviec 8, the skeleton of an adult male aged between 20 and 30, was also buried in a supine position next to Téviec 7 and 9 (Péquart *et al.*, 1937). Its right hand rested on the skull of Téviec 10, which lay beneath it, and contained a flint tool. The upper dentition was complete, but the lower first molars, incisors and right canine all appear to have been lost *ante-mortem*, probably through wear. A healed break was present in the left clavicle, and right ulna and radius (Boule and Vallois, 1937). Bone awls, a large pierced seashell (*Pecten maximus*) and two microliths were also associated with this skeleton.

Téviec 9

This skeleton of an adult female, between 25 and 35 years old, lay in a supine position, tangled with the skeletons of Téviec 8 and 10 (Péquart and Péquart, 1929). It included a complete skull and mandible, lacking only three upper incisors.

Téviec 10

Téviec 10, the skeleton of an adult female aged between 25 and 35 years, lay in direct contact with Téviec 9 (Péquart and Péquart, 1929). Its skull and mandible included an almost complete dentition, lacking only the upper right third molar. The skull was associated with a necklace, comprised of 442 shells.

Téviec 11

Téviec 11, the skeleton of an adult male, aged between 20 and 30 years, lay in a sitting position beneath several flagstones and a hearth. The skeleton of a two and a half year old child was found within its arms and both had been sprinkled with red ochre and decorated with pierced shells. The adult skeleton was also associated with three arm bracelets, a necklace, a retouched blade, a microlithic blade, a triangle, two trapezoids and the fragment of a stylet. Its dentition was complete.

Téviec 16

This skeleton of an adult male, 20-30 years old, appears to have been the first burial interred within the mass grave, completely separated from the other skeletons by a layer of cooking debris (Péquart *et al.*, 1937). It lay on a paved surface in extended supine position with the skull and the shoulder raised by a large rock pillow and covered by a large flagstone. The skull and mandible contained a complete dentition. Two flint projectiles were discovered embedded in the eleventh and six vertebrae, representing the probable cause of death. Three retouched blades, two arm bracelets

and tools made from bone, stone and antler, as well as numerous shells were associated with this skeleton.

Cabeço da Arruda

The site of Arruda forms part of a complex of shell middens located on the lower terraces of the Muge River, near to the modern town of Muge, Northeast of Lisbon, Portugal (Fig. 7.5.1). The Arruda midden is situated on the left bank of the river and measures 95m by 45m and is 5m deep (Roche, 1965). It has undergone several phases of excavation: Pereira da Costa was the first to excavate the site in 1865, uncovering about 45 hominin skeletons; followed by Riberio 1890 who discovered a further 100 skeletons; Paula e Oliveria in 1892; da Serpa Pinto and colleagues in 1937, and finally by Roche between 1964 and 1965, uncovering a further 13 individuals (Newell *et al.*, 1979).

Dating

Five occupation layers were uncovered at the site; the lower layers were radiocarbon dated to 6430 ± 300 BP and the upper layers to 5610 ± 300 BP (Roche, 1965; Roche, 1989). More recently a new radiocarbon date, of 7550 ± 100 BP, was obtained from one of the skeletons (Cunha and Cardoso, 2001).

Tool industries

The flint tool industry from Arruda was poor, characterised by many trapezoids and a few triangles (Roche, 1965). The bone and antler industry, however, was both rich and varied, including awls, bodkins, borers, polished ribs and a polished axe (Newell *et al.*, 1979; Roche, 1965).

Non-human fauna

It was not possible to find published information on animal remains from this site, but the results of stable isotope analysis on the hominin teeth suggests a 50:50 split between marine and terrestrial fauna in the diet (Lubell *et al.*, 1994).

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

Unfortunately, none of the hominin skeletons uncovered during the excavations at Arruda have been formally described and those excavated during earlier campaigns are without a stratigraphic context. However, the hominin skeletons excavated by Roche came from the bottom of the Mesolithic levels and were found in shallow graves or pits, generally in supine, contracted and extended positions (Newell *et al.*, 1979).

Arruda 81.47.4.C3

This adult skull and mandible contained a complete dentition.

Arruda 81.61.5 C1

The skull of this adult included a maxillary fragment, containing the right first and second molars. The mandible was more complete, but lacked the lower third molars, the left fourth premolar and two incisors.

Arruda 81.61.5 C6

This adult skull and mandible contained most of the dentition, lacking two upper incisors, the lower right third premolar and two lower incisors.

Arruda 81.61.5 CII

This mandibular fragment of an adult contained the lower right first and second molars and fourth premolar.

Arruda 81.61.5 OV

The skull and mandible from this adult included an almost complete dentition, only lacking the upper right third molar and the lower left third molar and canine.

Arruda 81.73.7 56

This adult mandible contained an almost complete dentition, lacking only the lower right first incisor.

Arruda Esq 3

The remains of this adult skeleton included a complete mandible, lacking only the left first molar, and a maxillary fragment, containing the left first and second molars and premolars.

Arruda Esq 6

This adult mandible lacked the left third and second molars.

Arruda Esq 8

The skull and mandible of this young adult contained a complete dentition, lacking only the lower right fourth premolar. The third molars were present but unerupted, attesting to the young age of this individual.

This collection of hominin skeletons from the site of Arruda contained varying levels of tooth wear, with most individuals possessing either slight or heavy amounts of wear. Comparisons with the Mesolithic population from the neighbouring site of Moita do Sebastião have suggested that the individuals from Arruda displayed a significantly slower rate of tooth wear (Lubell *et al.*, 1994). In a study of their dentitions Lubell *et al.* (1994) found they had an occlusal caries rate of 7.3% in the lower molars, and Cunha and Cardosos (2001) noted that 29% of the adult teeth showed evidence for linear enamel hypoplasia.

Moita do Sebastião

Moita do Sebastião is part of a complex of shell middens, including the site of Cabeço da Arruda, located on the banks of the River Muge, northeast of Lisbon, Portugal (Fig. 7.5.1). Ribeiro and Ribeiro were the first to excavate the site in 1890, followed by de Paula e Oliveria in 1892, and Roche between 1952 and 1954. Whilst little is known of the graves uncovered during the early excavations, Roche (1989) uncovered at least 26 graves, containing about 56 individuals, within the lowest Mesolithic layer, III, associated with several habitation structures, as well as shallow and deep pits (Roche, 1989).

Dating

Layer II, located directly above Roche's burials, was radiocarbon dated to between $7,350 \pm 350$ and 7080 ± 130 BP (Roche, 1989). The hominin remains have also been radiocarbon dated to 7120 ± 40 BP (Cunha and Cardoso, 2001).

Tool industries

Roche (1965) noted the presence of a crude tool industry made from quartzite and flint, including microliths and with a predominance of trapezoids and triangles.

Non-human fauna

The shell midden was dominated by the remains of crustaceans, such as crab (*Carcinus moenas* and *Gelasimus tangeri*); molluscs (*Cardium edule* and *Helix* sp.), mussels (*Mytilus edulis*), *Neritina fluviatilis* and *Scrobicularia plana* were also present (Roche, 1965). The mammalian assemblage contained the remains of hedgehog (*Erinaceus europeae*), rabbit (*Oryctolagus cuniculus*), hare (*Lepus* sp.), lynx (*Lynx pardinus*), otter (*Lutra lutra*), badger (*Meles meles*), fox (*Vulpes vulpes*), wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and aurochs (*Bos primigenius*). Stable isotope analysis of the hominin teeth suggests a 50:50 split between the marine and terrestrial fauna contribution to the protein in their diet (Lubell *et al.*, 1994)

Flora

It was not possible to find published information on plant remains from this site.

Hominin remains

According to Roche (1972) the skeletons had been buried using a definite funeral ritual; the bodies were laid out in contracted supine positions on a sandy surface within natural depressions and organised into two groups of unequal size always situated outside the dwelling zone (Roche, 1989).

H1A

This skeleton of an adult female included the skull, mandible and a fragmentary post-cranial skeleton. The maxilla contained the molars, the right fourth premolar and the left third premolar. The mandible lacked the right third molar, third premolar and canine.

H7

This grave contained the skeletons of a mature adult female and baby of several months. The adult maxilla contained the right third molar, the second and third molars, the right fourth premolar, the left canine and first incisor.

H9

This adult mandible contained a complete dentition.

H11

The skull of this adult female included the upper left molars and the fourth premolars. The associated mandible contained a complete dentition.

H14

This mandible of an adult male contained all the left upper teeth, as well as the right first and second molars.

H16

The skeletal remains of this mature adult female included a skull and mandible. The third molars, the left first molar, the right fourth premolar and an incisor were missing from the maxilla, while the mandible lacked the second molars and the left third molar.

H17

The skull of this adult male lacked the upper molars, the left fourth premolar and an incisor. The left third molar and premolars, as well as two incisors were missing from the associated mandible.

H19

The skeletal remains of this adult female included a complete skull and mandible, lacking the upper third molars, right third premolar and an incisor.

H21

This adult mandible contained a complete dentition.

H22

The skeleton of this adult included a mandible, lacking the first and second molars, as well as the right fourth premolar.

H23

This adult skull retained the upper second molars, the right first molar, the left premolars and canine, and two incisors.

H26

This adult skeleton included a mandible with the lower left molars and fourth premolar.

H27

This adult mandible lacked the left premolars and two incisors.

H28

The maxilla of this adult skeleton contained the right first molar, premolars and canine.

H30

The skeleton of this adult male included a mandible missing the left third molar and the right fourth premolar.

H32a

This adult female skeleton included the skull and mandible, containing the upper first and second molars, the fourth premolars, and the lower left molars.

H34

The mandible from this adult male skeleton included the left first molar and fourth premolar.

H35

The skeleton of this adult included a maxillary fragment, containing the left molars and fourth premolar and an almost complete mandible, lacking the right second molar.

HZ

This partial skull of an adult contained most of the upper dentition, lacking only one incisor. The associated mandible lacked the left first molar and all the incisors.

The hominins from Moita do Sebastião showed varying amounts of tooth wear from slight to heavy. An occlusal caries rate of 14.3% was observed by Lubell & Jackes (1994) in the lower molars, almost double that of the Mesolithic population from the neighbouring site of Arruda. Evidence for linear enamel hypoplasia was also found in 29% of the adult teeth (Cunha and Cardoso, 2001).

7.6 Neolithic Modern Humans

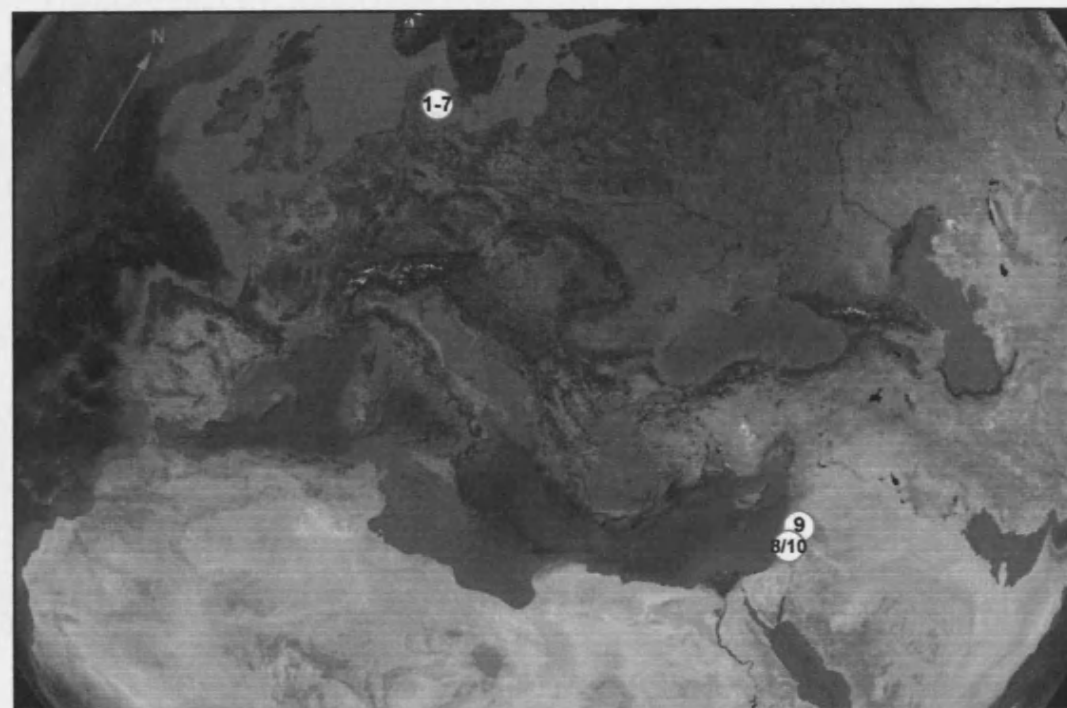


Figure 7.6.1: Neolithic sites included in this study. 1.Bidstrup, 2.Borreby, 3.Juelsberg, 4.Kyndeløse, 5.Rævehøj, 6.Svinø, 7. Uggerselevgaard, 8.Abou Gosh, 9.Atlit Yam, 10.Hatoula.

Sites from southern Scandinavia

A large collection of Neolithic skeletons from southern Scandinavia is housed at Panum museum in Copenhagen, Denmark (Fig. 7.6.1). Many of them came from passage graves and burial cists that were excavated at the end of the 19th century and beginning of the 20th century, but have never been published. A brief description of the sites and a more detailed description the hominin remains was provided by Bröste *et al.* (1956).

Bidstrup

Bidstrup is a passage grave, containing a single, rectangular chamber, approximately 8m long. Henri Petersen excavated the grave in 1871, discovering several burials and stone tools. Six individuals were discovered in the southern passageway associated with Middle Neolithic artefacts including, an arrowhead, a transverse arrowhead and two amber beads. The remains of several more individuals were found in the heavily

disturbed northern passageway, associated with Middle and Late Neolithic artefacts. Two individuals, both found in the southern passageway, have been included in the current study.

Bidstrup I

The skeleton of this adult male included a well-preserved skull, containing the right third molar, the first and second molars, the right premolars, canine and incisors. The left premolars were also present, but had been badly damaged and the remaining teeth showed moderate to heavy wear.

Bidstrup VI

This skull and mandible had lost many of the teeth *post-mortem*, but the mandible still contained the molars, the right fourth premolar, the left third premolar and the right canine. The maxilla contained the molars and premolars. All of these teeth, except for the third molars, were heavily worn.

Borreby

This passage grave, containing a 5m long oval chamber, 11 upright stones, three capstones and a passageway, was discovered and excavated by Worsaae in 1859. The skeletal remains of at least 60 individuals were discovered within both the chamber and passageway, associated with artefacts dating to the Late Neolithic, including daggers, arrowheads, bone pins, potsherds and a Middle Neolithic axe. Nine adults from this collection have been included in the current study and most of their teeth, apart from Borreby XVII, possessed moderate to heavy amounts of wear.

Borreby I

This adult male was represented by a well-preserved skull and cranium. The dentition was almost complete, missing three upper incisors and the right third molar.

Borreby II

The remains of this adult male included a complete skull and mandible. The upper right first incisor and the left third molar were missing from the maxilla and many teeth had been lost from the mandible, post- and *ante-mortem*, with only the right second molar, the first molars, the fourth premolars and the right canine still present.

Borreby III

This skeleton of a mature adult male included a skull and mandible. The maxilla contained the second molars, the right first molar, the premolars and the canines, and the lower second molars, the fourth premolars, the right third premolar, the canine and the left second incisor were still present within the mandible.

Borreby VII

The skull and mandible of this adult male lacked the upper right third molar, the third premolars and three incisors as well as the lower left fourth premolar and two incisors.

Borreby IX

This skeleton of a mature adult male included a skull and mandible, lacking the upper right third molar, fourth premolar, canine and second incisor as well as the lower right third premolar.

Borreby XVI

This skeleton of a mature adult female included a skull and mandible. The incisors, the left canine and the left third molar were missing from the maxilla and the mandible lacked the incisors and the right third molar.

Borreby XVII

The skull and mandible of this adult female contained a relatively incomplete dentition. The upper first molars, the premolars and the canines were still present within the maxilla and the mandible contained the first molars, the right canine and an unerupted left third molar.

Borreby XXIII

The skull of this adult female contained an almost complete dentition, lacking only the upper right third molar.

Borreby XXIV

This skeleton of an adult female included a skull, lacking the upper left third molar, canine and three incisors.

Juelsberg

This cist grave, approximately 4m in length and constructed out of ten upright stones, was discovered within a tumulus. Helweg Mikklesen excavated the grave in 1939,

discovering the remains of five individuals within the cist and ten in a pile directly outside it. These remains were associated with ornamental bone pins and stone tools, such as daggers and arrowheads, all dating to the Late Neolithic. Two of the individuals found within the cist have been included in the current study.

Juelsberg I

This skull and mandible contained the upper molars, the premolars and left first incisor as well as the lower left first and second molars and premolars. While all the upper teeth were heavily worn, the lower teeth possessed only slight to moderate amounts of wear, suggesting they may have belonged to different individuals.

Juelsberg II

This skeleton of an adult male included a well-preserved skull and mandible. The dentition was only slightly worn and almost complete, lacking the upper right first molar, which appears to have been lost *ante-mortem*.

Kyndeløse

This double passage grave contained two oval-shaped chambers, one north and one south. Thorvilden excavated the grave in 1938, discovering 58 hominin skeletons in the northern chamber and at least 15 in the southern chamber. The northern chamber was divided into two layers separated by a layer of sand: the lower layer contained 50 co-mingled skeletons associated with Middle Neolithic artefacts, such as axes, chisels and pottery, as well as amber and bone beads; the upper layer contained the remains of only eight skeletons associated with a single flint dagger. Bröste *et al.* (1956) were able to separate 24 skeletons from the northern chamber, identifying 22 adults and two juveniles, of which ten were females and 14 males. Eight of these individuals have been included in the current study. Most of their teeth showed slight to moderate wear, apart from Kyndeløse I and III whose teeth were heavily worn.

Kyndeløse I

The skull of this mature adult female contained the upper right third molar, the second molars, the left first molar and third premolar.

Kyndeløse III

This skeleton of a mature adult male included a skull, lacking the third molars and three incisors.

Kyndeløse IV

The skull and partial mandible of this adult female lacked many teeth. Only the first molars, the left fourth premolar and canine were still present within the maxilla and the mandible lacked all four incisors, the right third premolar, the left second molar and the third molars.

Kyndeløse X

This skeleton of an adult female included a partial skull and the upper left second and first molars, premolars and two incisors.

Kyndeløse XII

The partial skull of this young adult male contained the second and first molars, the premolars and two incisors.

Kyndeløse XXII

This skeleton of an adult female included a partial skull and the upper right third molar, the second and first molars, the left premolars and the right canine.

Kyndeløse XXIII

The partial skull and complete mandible of this mature adult male lacked all of the upper teeth, but the lower first and second molars and the right fourth premolar were present within the mandible.

Kyndeløse XXVI

This skeleton of an adult male included a partial skull and complete mandible, containing an almost complete dentition, lacking only the upper left third molar.

Rævehøj

This passage grave, containing a rectangular chamber 7.8m long, 16 upright stones, five capstones and a passage, was discovered within a tumulus. Rosenberg excavated this site in 1914, discovering the scattered remains of 92 hominin skeletons associated with Middle and Late Neolithic artefacts, including arrowheads, dagger blades and bone points. Twenty-seven of the skeletons were assigned a sex and age category and four have been included in the current study. Most of their teeth possessed slight to moderate amounts of wear.

Rævehøj II

This adult female skeleton included the skull and part of the mandible. The maxilla contained an almost complete dentition, lacking only the left third molar, while only the right molars, premolars and canine were present in the partial mandible.

Rævehøj VIII

The skull and mandible of this adult female contained a complete lower dentition and the upper molars and premolars.

Rævehøj XV

This skeleton of an adult male included a skull and mandible with an almost complete dentition, lacking only the upper first incisors.

Rævehøj XVI

The skull of this adult male contained an almost complete upper dentition, lacking only the right first incisor and third molar.

Svinø

Thomsen excavated this double passage grave, containing two chambers, 11.5m in length and divided by a single stone in 1908. A 50 cm thick deposit was discovered, containing the scattered remains of several hominins associated with artefacts from the Middle Neolithic. One of these skulls has been included in the current study.

Svinø I

This skull and mandible belonged to a mature adult female and many of the teeth appear to have been lost ante- and *post-mortem*. The right first molar, fourth premolar, canine and the second incisors were still present within the maxilla and the mandible contained the right molars, premolars and canine.

Uggerselvgaard

This passage grave was discovered within a tumulus, comprising a single rectangular chamber, 7.5m long, a passageway, 16 upright stones and five capstones. Madsen excavated the site in 1892, discovering the co-mingled remains of at least 86 hominins within the chamber and passageway. They were associated with Middle and Late Neolithic artefacts, such as thick-butted axes, chisels made from flint and bone, amber beads, potsherds and an antler pendant. Two individuals from this collection have been included in the current study.

Uggerslev I

This adult male skeleton included the skull and mandible, containing the upper first molars, the left fourth premolar, the third premolars and the canines, and all the lower teeth apart from the incisors. All the remaining teeth showed moderate amounts of wear.

Uggerslev II

The skull and mandible of this adult female contained the upper first and second molars, the premolars and the canines and most of the lower teeth, lacking only the left incisors and the right first molar. The remaining teeth were only slightly worn.

Abou Gosh

The site of Abou Gosh is an open-air settlement located within the Judean hills, 700m above sea level, near the modern village of Abou Gosh and about 12 km from Jerusalem, Israel (Fig. 7.6.1). Perrot (1952) was the first to excavate the site in 1950 and Lechavallier (1978a) undertook more major excavations between 1967 and 1971, revealing deposits from the middle or late Pre-Pottery Neolithic B (PPNB) and the Byzantium period. The PPNB layers covered an area about 2000 m², containing several rectangular houses, various other structures and the remains of about 30 hominins (Lechavallier, 1978a).

Dating

The erosion of the PPNB deposits at Abou Gosh combined with Byzantine intrusions meant the excavators were unable to obtain reliable radiocarbon dates. The associated tool industries, structures and burials provide a date of 8-9,000 BP and the beginning of MIS 1 (Lechavallier, 1978b).

Tool industries

Over 18,000 lithic pieces were collected from the PPNB levels, comprised mainly of debitage and made from a local source of flint (Lechavallier, 1978e). The most common tool types were sickle and retouched blades, with arrowheads, burins, scrapers, borers, points and axes also represented (Lechavallier, 1978e). Some containers were made from very fine limestone, including bowls, basins, vases and plates. Milling equipment, such as grinding stones, cutting wheels and pestles were also discovered. The tool assemblage included a range of bone tools, mostly points, needles and spatulas and eleven animal and abstract figurines (Lechavallier,

1978c;Perrot, 1952). This tool industry dates to site to the Pre-Pottery Neolithic B (PPNB).

Non-human fauna

The remains of domestic goat (*Capra hircus*) dominated the non-human faunal assemblage with wild boar (*Sus scrofa*), gazelle (*Gazella* sp.) and fallow deer (*Dama mesopotamica*) were also common (Ducos, 1978). A number of mollusc shells were discovered within the Neolithic layers, including land snails (*Buliminus labrosus* and *Levantina hierosolyma*) and cockles (*Glycymeris violascens*, *Rudicardium tuberculatum* and *Cerastoderma glaucum*), and most appear to have been used as pendants (Mienis, 1978).

Flora

Although plant remains were not recovered from the Neolithic levels at Abou Gosh, the high number of sickle blades, millstones, pestles and mortars suggests they played an important role in the diet of its inhabitants (Lechavallier, 1978b).

Hominin remains

Thirty individuals were discovered at Abou Gosh; three children, eight adolescents and 22 adults (Arensburg *et al.*, 1978). Most of these remains came from single burials, while a number of disarticulated pieces were found throughout the site. Six of the adults have been included in the present study.

193

This isolated mandible contained most of the lower teeth, lacking only three incisors.

747.4

This skeleton of an adult male lay on its left side in a flexed position next to the skeleton of another adult male (747.5) and included the left part of the mandible and three molars (Arensburg *et al.*, 1978;Lechavallier, 1978f). It formed part of a group burial, containing the additional remains of two adults, two adolescents and an infant skeleton.

747.5

This complete, but fragmented skeleton of an adult male, aged between 35 and 45 years, was found next to 747.4 (Arensburg *et al.*, 1978;Lechavallier, 1978f). It included

a fragmentary skull and a well-preserved mandible, missing only the lower right incisors.

798

This maxillary and mandibular fragment contained the upper right second and third molars and canine, and the lower left first and second molars, premolars and canine.

842

This isolated mandible lacked the left first and third molars.

848

This mandibular fragment contained the left first and second molars and the third premolar.

Heavy tooth wear was observed in many of the mature adults from Abou Gosh, but varied throughout the population. Antemortem tooth loss was noted in two of the mandibles and in both cases involved the first molar. Periapical abscesses were observed in two additional mandibles (Arensburg *et al.*, 1978). There was limited evidence for the presence of caries or periodontal disease within the dentitions.

Atlit Yam

Atlit Yam is a submerged, open-air settlement located 3–400m off the Israeli coast, 10 km south of Haifa Bay and 8–12m below sea level (Fig. 7.6.1). Underwater excavations uncovered several rectangular stone structures, a water well, paved areas, pits, hearths, lithic and bone tools, non-human bones, well preserved organic material and the remains of 24 hominin skeletons (Galili, 1987; Galili *et al.*, 1989).

Dating

Charcoal from the hearths was radiocarbon dated to 8000 ± 90 BP and 8140 ± 120 BP (Galili, 1987). These dates place the site at the end of the PPNB and the beginning of the Pre-Pottery Neolithic C (PPNC). This date is supported by the associated tool industry.

Tool industries

The stone tool assemblage was dominated by flakes and arrowheads with sickle blades and bifaces also numerous (Galili *et al.*, 1989). Arrowheads, notched pieces,

denticulates, bifacially flaked knives and strangled blades, as well as grinding stones, mortars, pestles and bowls were present, but in low numbers. The arrowheads were dominated by Byblos and Amuq-type points, characteristic of the middle and late PPNB and those typical of the early PPNB, such as Helwan points, were absent (Galili *et al.*, 1989). All of the raw material for the lithic tools came from the nearby Mount Carmel region (Galili *et al.*, 1989). The bone tool assemblage contained spatulas, blade handles, needles and fragmented points (Galili *et al.*, 1989). Ornamental objects were also discovered at the site, including decorated and engraved bones, grooved and perforated stones, bracelets, engraved heads of animals, and a stone phallus (Galili *et al.*, 1989).

Non-human fauna

The remains of domestic goat (*Capra hircus*) and bovid (*Bos* sp.) dominated the non-human faunal assemblage and wild boar (*Sus scrofa*), gazelle (*Gazella* sp.) and fallow deer (*Dama mesopotamica*) were also present (Horwitz and Tchernov, 1987). A high number of fish remains, mostly the offshore grey triggerfish (*Balistes carolinensis*), were discovered and suggested that the inhabitants of Atlit Yam were adept fishermen (Galili *et al.*, 1989; Zohar and Dayan, 2001). This is supported by the presence of an auditory exostosis in one of the adult skulls, indicative of long periods of exposure to cold water (Hershkovitz and Galili, 1990).

Flora

Thousands of seeds from about 90 different plant species were discovered at the site, including: domestic grains, represented by naked wheat (*Triticum parvicoccim*), emmer wheat (*Triticum dicocum*) and barley (*Hordeum vulgare*); domestic pulses, such as lentils (*Lens culinaris*) and chickpeas (*Cicer arietinum*); and fruits, including fig (*Ficus carica*) and wild grape (*Vitis sylvestris*) (Kislev *et al.*, 2004). Analyses of wood charcoals found in the hearths at Atlit Yam also showed that oak (*Quercus*) and pistachio (*Pistacia*) trees were a major source of fuel (Galili *et al.*, 1989).

Hominin remains

Twenty-four hominin skeletons, in various states of preservation, were found at the site, including five children, two adolescents and 17 adults (Hershkovitz and Galili, 1990). They were spread over a large area located close to or within dwellings. The skeletons came from both primary and secondary, and individual and double burials (Galili *et al.*, 1989; Hershkovitz *et al.*, 1991). Eight individuals have been included in the current study.

H1

The skeleton of this adult female, c. 20 years old, was extremely well preserved and almost complete (HersHKovitz and Galili, 1990). It lay on its right side in a flexed position with the knees close to the chest. It included a skull and mandible, which lacked the upper incisors and third molars and the lower canines and incisors. The vertebrae showed evidence of spondylolysis (osteoarthritis of the spine).

H09

This skeleton of a mature adult male lay in a flexed position below a pile of charcoal and some of the bones showed evidence of burning (HersHKovitz and Galili, 1990). It included a mandible, missing the left third molar, right canine and an incisor.

H28

This individual was represented by an isolated mandible, lacking the third molars and the right first incisor.

H29

This mandible lacked the molars and one incisor. All of the molars appear to have been lost *ante-mortem* with substantial alveolar resorption.

H35

This mandible lacked the third molars, the left third premolar and three incisors.

H67

These remains included an almost complete maxilla and partial mandible. They contained all of the upper teeth, except one incisor, and the lower right molars, the fourth premolars, the left third premolar, canine and second incisor.

H88

This maxilla and associated mandible contained an almost complete dentition, lacking only the lower incisors.

H91

A partial maxilla and mandible represented the remains of this individual, containing the upper right second molar, the first molars, the right fourth premolar, the third premolars, the canines and three incisors, and the lower second molars, the left first molar, premolars, the right canine and the incisors.

All of the individuals from Atlit Yam possessed various degrees of dental hypoplasia and dental calculus (Hershkovitz and Galili, 1990). The heavy tooth wear found on the occlusal and labial surfaces of many of the individuals from Atlit Yam has been attributed to their use in processing ropes or leather straps and the mastication of stone ground food (Galili *et al.*, 1989; Hershkovitz and Galili, 1990). The amount of wear varied throughout the group.

Hatoula

Hatoula is an open-air site located on south bank of the Nahal Nahshon, within the western margins of the Judean Shefela, 215m above sea level and 20 km west of Jerusalem, Israel (Fig. 7.6.1). Lechevallier and Ronen (1985; 1994a) excavated the site during the 1980s, identifying three periods of occupation; the Late Natufian, Khiamian and PPNA (Sultanian) (Bar-Gal *et al.*, 2003; Lechavallier and Ronen, 1994a). These levels contained evidence of dense hominin occupation, but only the Khiamian and Sultanian layers contained pits and large dwelling structures (Lechavallier and Ronen, 1994b). Nine hominin skeletons were discovered; one from the Natufian level and eight from the Khiamian/Sultanian (Le Mort, 1994).

Dating

The Natufian levels were radiocarbon dated to $11,020 \pm 180$ BP, the Khiamian to $10,170 \pm 120$ BP, and the Sultanian to $10,030 \pm 140$ BP (Valladas and Arnold, 1994). These dates place the site at the end of MIS 2 and the beginning of MIS 1.

Tool industries

The Natufian stone tool assemblage was comprised of scrapers, burins, borers, backed, truncated, polished and retouched blades, retouched flakes and microliths (Ronen and Lechavallier, 1991). Borers, microliths, and retouched flakes and blades dominated the Khiamian tool assemblage, which also contained scrapers, burins, truncated and polished blades and arrowheads (el-Khiam points and Hagdud truncations) (Lechavallier *et al.*, 1994). The Sultanian tools were relatively sparse and dominated by retouched flakes and blades, and borers, with scrapers, burins, backed blades, notches, denticulates, geometric microliths, arrow heads (el-Khiam points and Hagdud truncations) and a few axes also represented (Lechavallier *et al.*, 1994). The Sultanian and Khiamian level also contained pestles, mortars and grinding stones. Altogether 185 bone artefacts were recovered from the levels at Hatoula; 26 from the

Natufian, 45 from the Khiamian, and 114 from the Sultanian, mostly represented by points and awls (Stordeur, 1994).

Non-human fauna

The remains of gazelle (*Gazella* sp.) dominated the non-human faunal assemblage from the Natufian and early Neolithic layers at Hatoula, with high numbers of aurochs (*Bos primigenius*), wild boar (*Sus scrofa*) and birds, such as duck (*Anas* sp.), partridge (*Alectoris chukar*) and quail (*Coturnix coturnix*) (Davis, 1985; Davis et al., 1994; Pichon, 1994). The remains of hartebeest (*Alcelaphus buselaphus*), equids (*Equus* sp.), sheep/goat (*Capra/Ovis*), fox (*Vulpes vulpes*), badger (*Meles meles*), wild cat (*Felis silvestris*), insectivores and rodents were also represented (Davis, 1985; Davis, 1994). Despite the site's geographical accessibility to fresh water fish a higher number of marine fish were discovered at the site, indicating evidence for fishing some 30 km away or trade with neighbouring communities (Davis, 1985; Lemaire and Lemaire, 1994). Over 200 marine shells were discovered and mostly came from cockles (*Glycymeris* and *Cardium*) and dentalia (*Dentalium*) (Bar-Yosef, 1994).

Flora

Samples taken from the Khiamian and Sultanian deposits both contained wheat and barley phytoliths with a high number of wild grass phytoliths also found in the Khiamian sample (Miller Rosen, 1994).

Hominin remains

Six skeletons from the Sultanian and Khiamian layers have been included in the current study.

H04

This highly fragmented skeleton of an mature adult, probably male, lay in strongly contracted prone position (face down) (Le Mort et al., 1994; Le Mort, 1994). The skull was absent, but the mandible was well preserved and retained the first molars, the right second molar, the fourth premolars, the right third premolar and the left second incisor. A stone bead was discovered near the distal end of the left humerus and represents a possible pectoral pendant (Le Mort, 1988).

H05

The well-preserved skeleton of a young adult male was found within this grave in a semi-flexed supine position with the skull resting on its right side (Le Mort, 1988;1994). It included a full dentition.

H07

This skeleton of an adult male lay was found in a contracted position (Le Mort, 1994). The skull was crushed, but two lesions were found on the temporal bone and are thought to have caused the death of this individual (Le Mort *et al.*, 1994). The mandible and the lower part of the maxilla were well preserved, retaining all the teeth, apart from the lower left third molar (possible agenesis). A stone bead was discovered near the left rib, possibly a pectoral pendant (Le Mort, 1994).

H08

The skeleton of an adult female lying in a crouched position was found within this burial (Le Mort *et al.*, 1994;Le Mort, 1994). The skull was incomplete and fragmented and the mandible lacked the left third molars, the right second molar and three incisors. A fragment of maxilla contained the upper right second and the first molars and the premolars. Two large rocks were located on top of the skeleton, one above the right arm and one above the left leg.

H09

This fragmentary skeleton of an adult female was positioned on its back in a strongly contracted position with the skull elevated (Le Mort, 1994). The skull was incomplete, but the mandible was well preserved, containing a complete dentition, though some had been broken *post-mortem*. A healed fracture was found on the right humerus (Le Mort *et al.*, 1994) and a bovid skull was associated with the burial (Le Mort, 1994).

H10

This badly preserved skeleton of an adult, probably female, lay in a supine position directly below the H09 burial (Le Mort, 1994). Fragments of the skull and a large portion of the mandible were preserved, including the lower molars and fourth premolars.

Dental hypoplasia was present in at least two teeth of all individuals from Hatoula and calculus was found at the roots of most adult teeth (Smith and Verdene, 1994). The rate of wear was severe, exposing secondary dentine in all five mature adults and was

also associated with *ante-mortem* tooth loss and large abscesses in H09. This pattern of dental disease and heavy tooth wear suggested that their diet contained large quantities of sticky, abrasive foods (Smith and Verdene, 1994).

7.7 Inuit of Igloolik

The Inuit of Igloolik form an island community, located in the north-eastern corner of the Melville Peninsula, Northwestern Territories, Canada. Dental research was conducted here and in the neighbouring community of Hall Beach as part of the International Biological Programme Human Adaptability Project between 1968 and 1973. Over 800 casts were collected from the local populations between 1969 to 1971 (Tomenchuck and Mayhall, 1979). Each person willing to cooperate in this study (over 90%) were examined to determine the number, condition and type of teeth present, the reason for loss of any tooth, and their periodontal condition and oral hygiene (Mayhall, 1972). Each person over two and a half years of age had alginate impressions taken, from which dental stone casts were made (Mayhall, 1972). It is from these stone casts that the amount of wear was recorded.

What is most noteworthy about this collection is that while this survey was undertaken the communities of both Igloolik and Hall Beach underwent extremely rapid acculturation. The Igloolik community was originally difficult to reach due to the isolation of the settlement and lack of a landing strip for planes (Mayhall, 1977). During this time few people had permanent employment and most lived off the land. Within four years the Igloolik settlement had become an administrative centre for the area and a landing strip was in use. This led to a rapid increase in opportunities for wage earning and less reliance on the land and an increased access to non-traditional foods (Mayhall, 1977).

Diet

The diet of the Igloolik population was discovered through direct questioning of all of the families. This survey ascertained an approximate percentage of their food intake that was made up of native foods (Mayhall, 1970). All of the adults from Igloolik had subsisted, at some point in the past, almost exclusively on native food (Mayhall, 1970). In 1969, most people were still subsisting on caribou, seal, fish, flour and tea with only approximately 30% consuming a diet made up of primarily processed foods (Mayhall, 1977). Notably, 50% of these individuals were under 16 years of age. By 1973 over 50% of people purchased their food, which contained large amounts of refined carbohydrates, such as chocolate bars, snack foods and canned soft drinks (Mayhall, 1977), but again 70 % of these individuals were under 16 years of age.

Material Culture

The change in diet amongst the Igloolik community was accompanied by a more general change in material culture as a result of increased contact with modern western culture. During the survey the uses of the teeth, for purposes other than mastication, were determined through observation and extensive informal interviews with local residents of all ages (Mayhall, 1977). It was noticed during the 1968-1973 survey that males hunted less than in former times and may now use tool implements rather than their teeth (Mayhall, 1972). Similarly, the females still actively use their teeth for sewing and softening rawhide for clothes, but far less due to the availability of rubber boots and modern clothing (Mayhall, 1972).

Dentition

The dental morphology of the Igloolik sample fell within the normal limits for modern Inuit populations (Mayhall, 1972); (Mayhall, 1977). The eruption sequences and dental development of Igloolik children were compared to French Canadian children (Mayhall, 1972). The results of this study showed that the permanent first molars in the maxilla and mandible erupted 6-10 months earlier in the Igloolik children compared to the French Canadian sample (Mayhall, 1972).

Tomenchuck and Mayhall (1979) measured tooth wear in casts of 46 females and 39 males using cusp height, mesio-distal length and bucco-lingual length of molar crowns. They found a good correlation between the level of tooth wear and the age of an individual. Sexual dimorphism in tooth wear was also evident in the rate of the wear of maxillary molars in females. It was found to be approximately 30% more rapid on male than on female maxillary molars. The authors propose that bruxism (grinding and clenching of the teeth) may be responsible for this difference.

Chapter 8 - Results

8.1 Neanderthals

The Upper Dentition (Fig. 8.1.1)

For the anterior teeth, the wear ratios (relative to the first molar) are high. In fact, in no individual was an upper incisor or canine less worn than the first molar in the same jaw. The median ratios of both incisors and the canines all cluster around 1.6 and their inter-quartile ranges overlap one another extensively. This is not what would be expected from the eruption sequence, which would suggest that the first molars and first incisors should show a similar level of wear with the second incisor possessing slightly less, and all greater than that of the canines. The anterior teeth also differ from the upper cheek teeth in their greater variation of wear ratio values. Their inter-quartile ranges are three or even four times those of the cheek teeth.

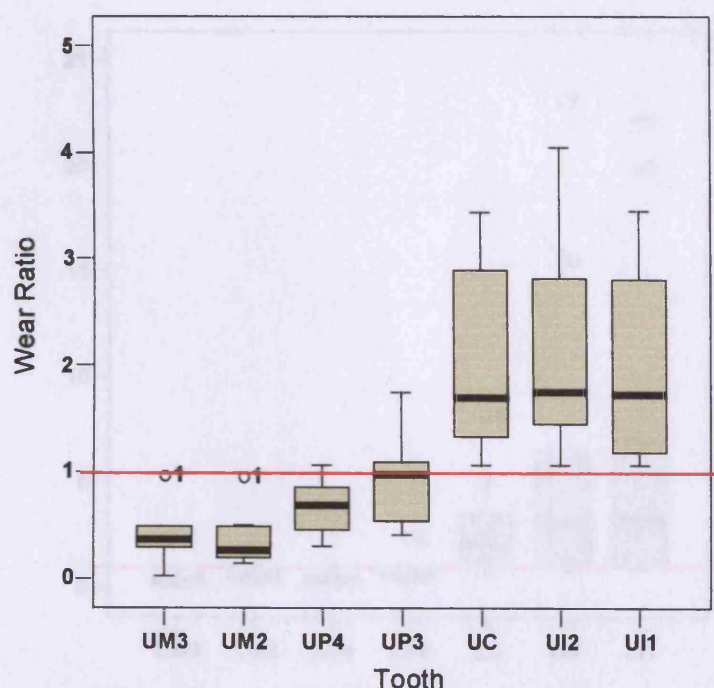


Figure 8.1.1: Combined Neanderthal wear ratios, relative to the first molar, for the upper dentition (standard scale 0-5).

The upper third premolar is at the crossover point of the graph, between the anterior and cheek teeth. Its median wear ratio is about 1, whereas the other upper cheek teeth all have median wear ratios of less than 1. In fact, although the third premolars' inter-quartile range does overlap 1, most of it is less than 1 and the tooth clearly belongs with the other cheek teeth in terms of its wear state. Together, the upper premolars have slightly higher median wear ratios and slightly higher inter-quartile ranges than the second and third molars. In term of eruption sequence, they would be expected to be similar to the second molar. The third molars have a median wear ratio slightly higher than the second molars and is in contrast to the eruption sequence which would predict the opposite pattern.

The Lower Dentition (Figs. 8.1.2-8.1.4)

The lower anterior teeth show strikingly higher median wear ratios (relative to the lower first molar), and much larger inter-quartile ranges, than the upper anterior teeth. The lower incisor median values are three times those of the first molar, and in some individuals incisor wear is more than six times that of the first molars from the same jaw. Even the canine median value is twice that of the first molar, but has a much smaller inter-quartile range than those of the incisors.

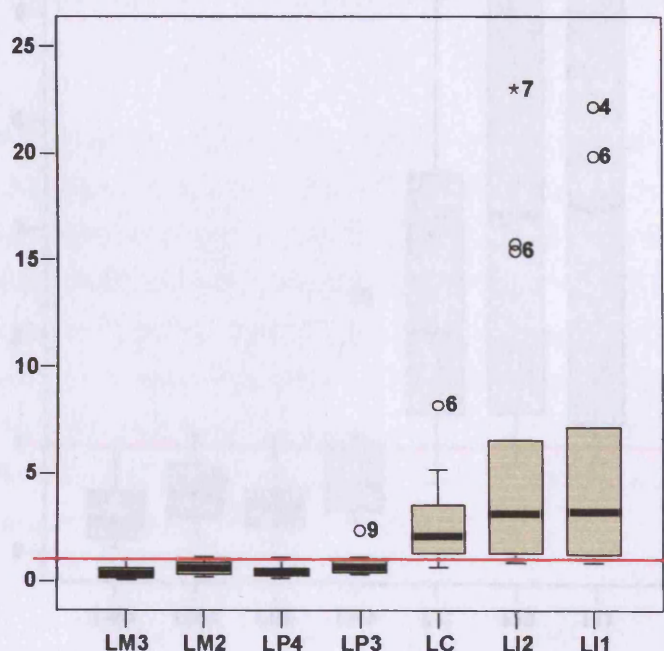


Figure 8.1.2: Combined Neanderthal wear ratios, relative to the first molar, for the lower dentition (scale reduced to 0-25 to include all outliers). For axis labels see Fig. 8.1.1.

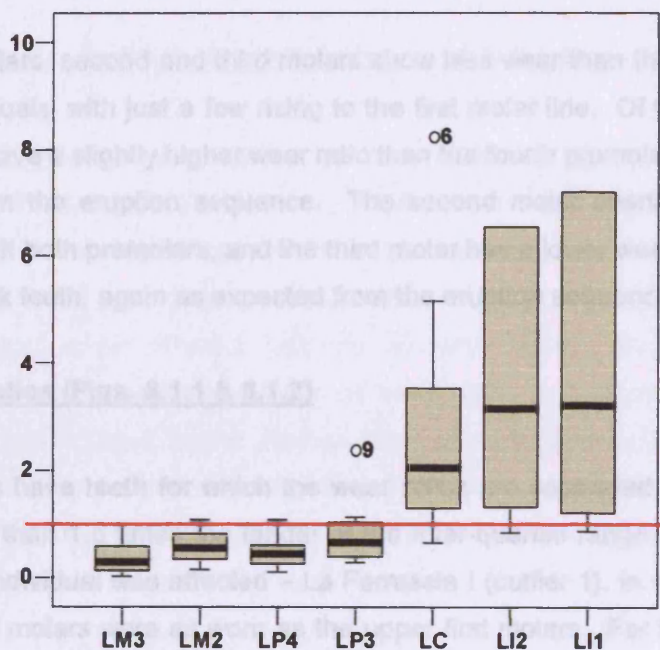


Figure 8.1.3: Combined Neanderthal wear ratios, relative to the first molar, for the lower dentition (scale reduced to 0-10 to include all boxplots). For axis labels see Fig. 8.1.1.

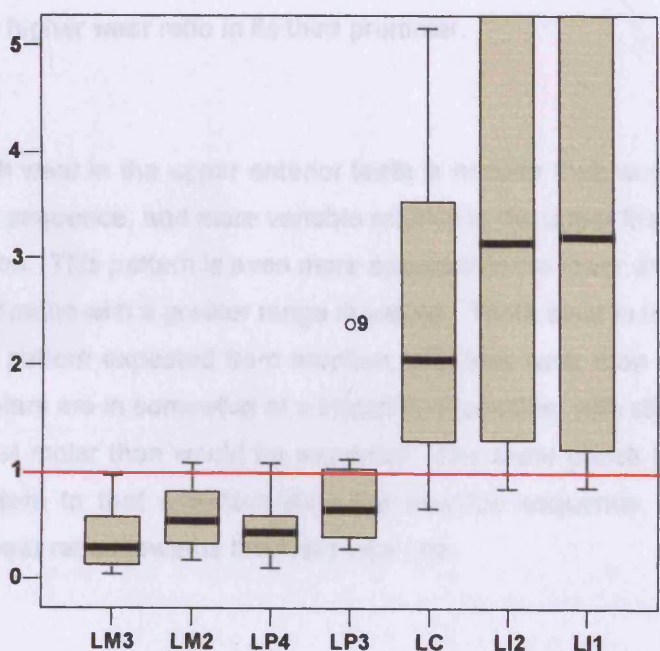


Figure 8.1.4: Combined Neanderthal wear ratios, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

The lower premolars, second and third molars show less wear than the first molars in almost all individuals, with just a few rising to the first molar line. Of these teeth, the third premolars have a slightly higher wear ratio than the fourth premolars, which would be expected from the eruption sequence. The second molar overlaps in its inter-quartile range with both premolars, and the third molar has a lower wear ratio than any of the other cheek teeth, again as expected from the eruption sequence.

Outlying wear ratios (Figs. 8.1.1 & 8.1.2)

A few individuals have teeth for which the wear ratios are separated from the upper quartile by more than 1.5 times the length of the inter-quartile range. For the upper teeth, only one individual was affected – La Ferrassie I (outlier 1), in which the upper second and third molars were as worn as the upper first molars. For the lower teeth, four individuals were affected, all with considerably greater anterior tooth wear relative to the first molar than in most other individuals. All came from the site of Krapina in Croatia. Krapina 59 (outlier 4) showed high wear ratios in its lower canines and incisors, whereas Krapina 55 (outlier 6) showed high levels in their incisors and Krapina 54 (outlier 7) in the first incisor. Just one individual, Krapina 58 (outlier 9), showed a slightly higher wear ratio in its third premolar.

Summary

In summary, tooth wear in the upper anterior teeth is heavier than would be expected from the eruption sequence, and more variable relative to the upper first molar than the rest of the dentition. This pattern is even more apparent in the lower anterior teeth with even higher wear ratios with a greater range in values. Tooth wear in the upper molars follows more the pattern expected from eruption, with less wear than the first molars. The upper premolars are in somewhat of a transitional position, with slightly more wear relative to the first molar than would be expected. The lower cheek teeth followed a more similar pattern to that expected from the eruption sequence, although some individuals had wear ratios towards the first molar line.

Male and female Neanderthals compared (Figs. 8.1.5 & 8.1.6)

The Neanderthal specimens were divided into male and female groups, based on the sexes identified in the literature (Table 8.1.1). This division was made because studies of recent hunter-gatherers have suggested strong differences in tooth use between the sexes (Pedersen, 1947). It is therefore reasonable to suggest that male and female Neanderthals might show different patterns of tooth wear. Male and female Neanderthals showed contrasting patterns of wear ratios in the upper teeth. The female Neanderthals showed higher median wear ratios in their anterior teeth, with larger inter-quartile ranges. Unfortunately, due to the low number of wear ratios for the female upper cheek teeth only limited conclusions can be drawn and all their median wear ratios fall within the range of the male values.

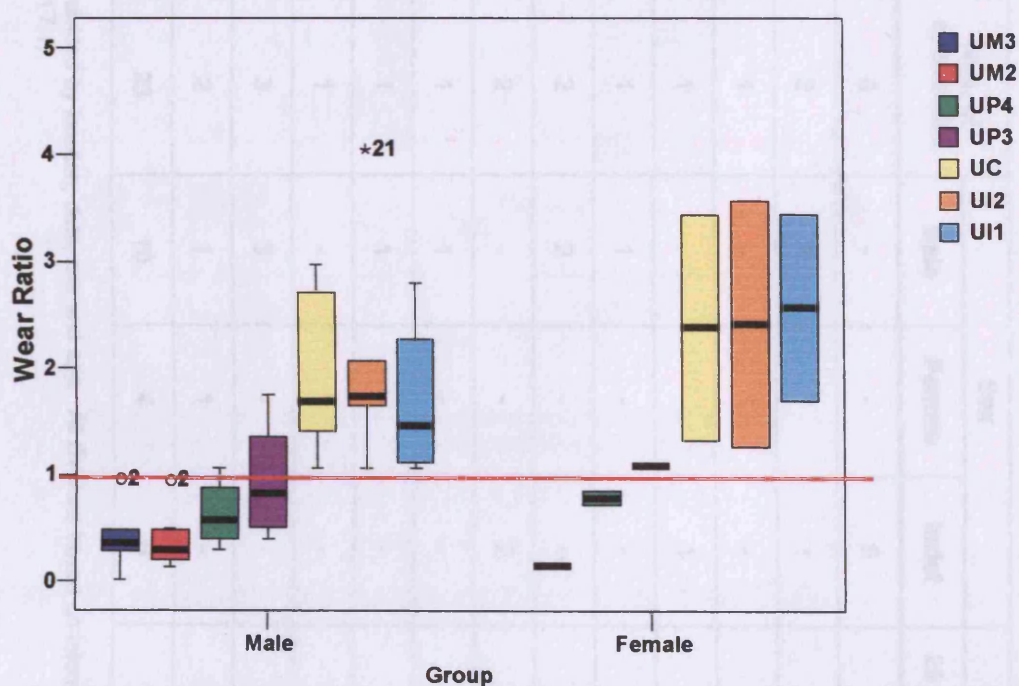


Figure 8.1.5: Male and female Neanderthal wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5).

Site	Location	Date Category	Nos. of specimens	Sex			Age Category	
				Male	Female	Indet	25 or under	Over 25
Krapina	C. Europe	Before 50,000 BP	6	-	-	6	6	-
La Ferrassie	W. Europe	After 50,000 BP	2	1	1	-	-	2
La Quina	W. Europe	Before 50,000 BP	1	-	1	-	1	-
Régourdou	W. Europe	50,000 BP	1	-	-	1	1	-
Saccopastore	W. Europe	Before 50,000 BP	1	1	-	-	1	-
Spy	W. Europe	After 50,000 BP	2	2	-	-	-	2
Vindija	C. Europe	After 50,000 BP	2	-	-	2	2	-
Amud	W. Asia	50,000 BP	1	1	-	-	1	-
Kebara	W. Asia	Before 50,000 BP	1	1	-	-	1	-
Shanidar	W. Asia	Before 50,000 BP	1	-	1	-	1	-
		After 50,000 BP	3	3	-	-	-	3
Tabun	W. Asia	Before 50,000 BP	2	1	1	-	-	2
Total			23	10	4	0	14	9

Table 8.1.1: Neanderthal specimens included in the current study, divided by location, date, sex and age. All divisions based on information gained from the published literature (for references see site and specimen descriptions in section 7.1).

Only a limited number of wear ratios were available for the female Neanderthal lower dentition, but they do show some contrasting results to the male group. In the female group, the anterior teeth show much higher median wear ratios. In fact, none of their wear ratios fall within the inter-quartile ranges of the male group. In contrast the wear ratios of the cheek teeth from the female group fall within the inter-quartile ranges of the male wear ratios, apart from the third premolar, which has a much higher median wear ratio of about 1.

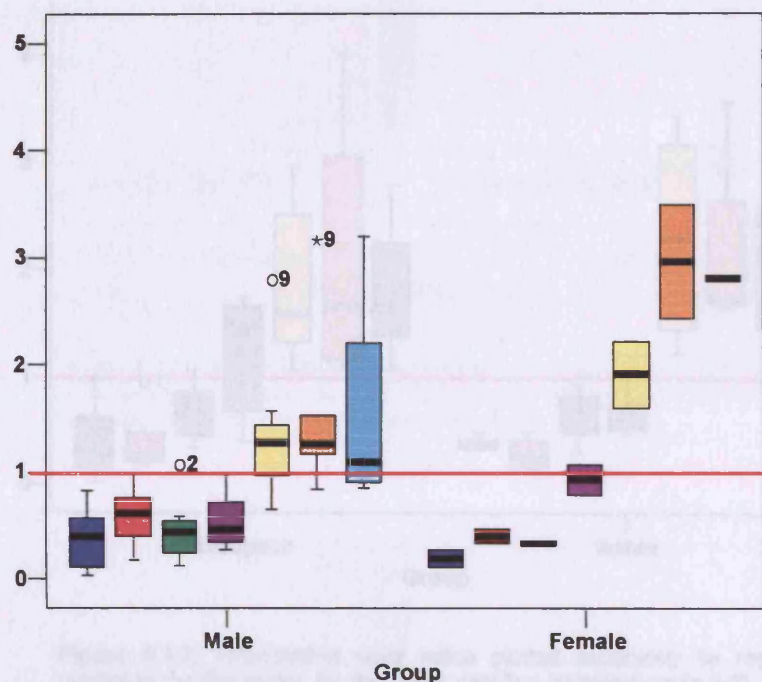


Figure 8.1.6: Male and female Neanderthal wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

European and Asian Neanderthals compared (Figs. 8.1.7-8.1.9)

The Neanderthals specimens were also divided into two groups based on their European or Asian origin (Table 8.1.1). This division was made as it might be expected that the availability of resources would have varied between regions and this may have lead to differences in wear patterns. In the upper dentition, the pattern of wear ratios is similar for European and Asian Neanderthals. The exceptions are the upper third premolars for which the median wear ratio is much higher in the European Neanderthals. In addition, the inter-quartile ranges of all cheek teeth are larger in the

European Neanderthals, particularly for the third premolars. Median wear ratios for the incisors are similar in both groups. The canine wear ratios are, however, somewhat higher in the Asian group. The cheek teeth show similar median wear ratios, apart from the third premolars, which are above 1 in the European group and have a much larger inter-quartile range.

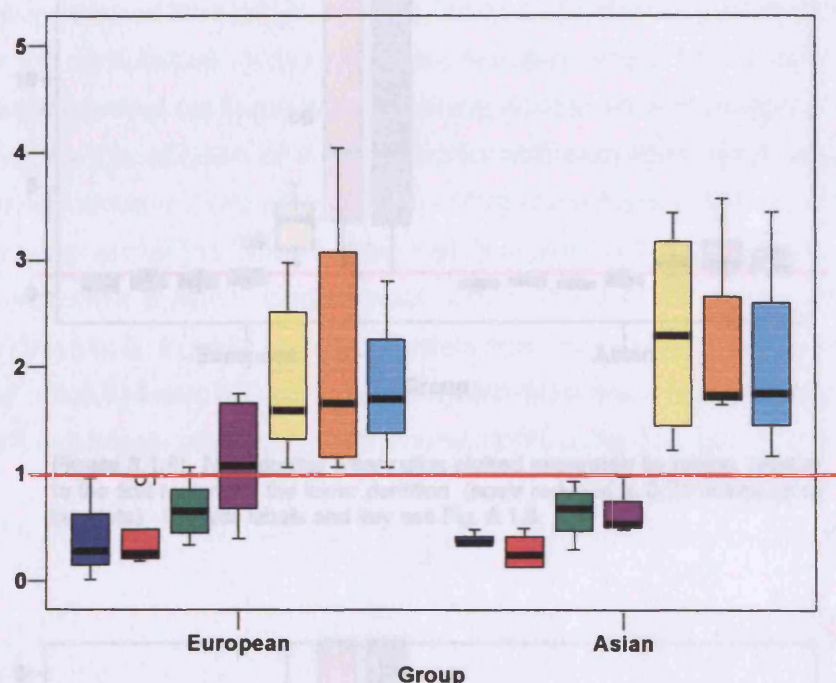


Figure 8.1.7: Neanderthal wear ratios plotted separately by region, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In the lower dentition, there is a much greater contrast between European and Asian Neanderthals. In the Europeans, the anterior teeth show much higher median wear ratios and very greatly increased inter-quartile ranges. This is particularly apparent in the incisors. In the Asians, the wear ratios of all anterior teeth are only slightly greater than 1. It is apparent that almost all of the anterior tooth wear pattern seen in the combined Neanderthals graph above results from individuals in the European groups and within this, it is particularly the individuals from Krapina. The cheek teeth in the European Neanderthal group show greater variation in their wear ratios; the premolars have a much higher median wear ratio of 1 and the second molars also have a higher median of wear ratios.

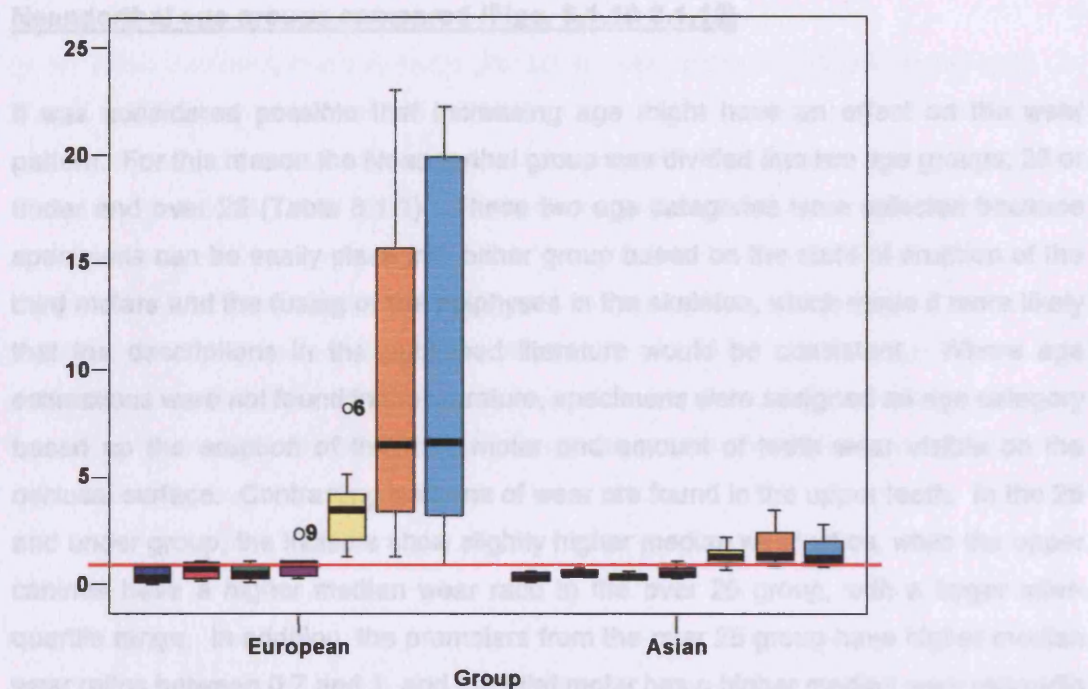


Figure 8.1.8: Neanderthal wear ratios plotted separately by region, relative to the first molar, for the lower dentition (scale reduced to 0-25 to include all boxplots). For axis labels and key see Fig. 8.1.6.

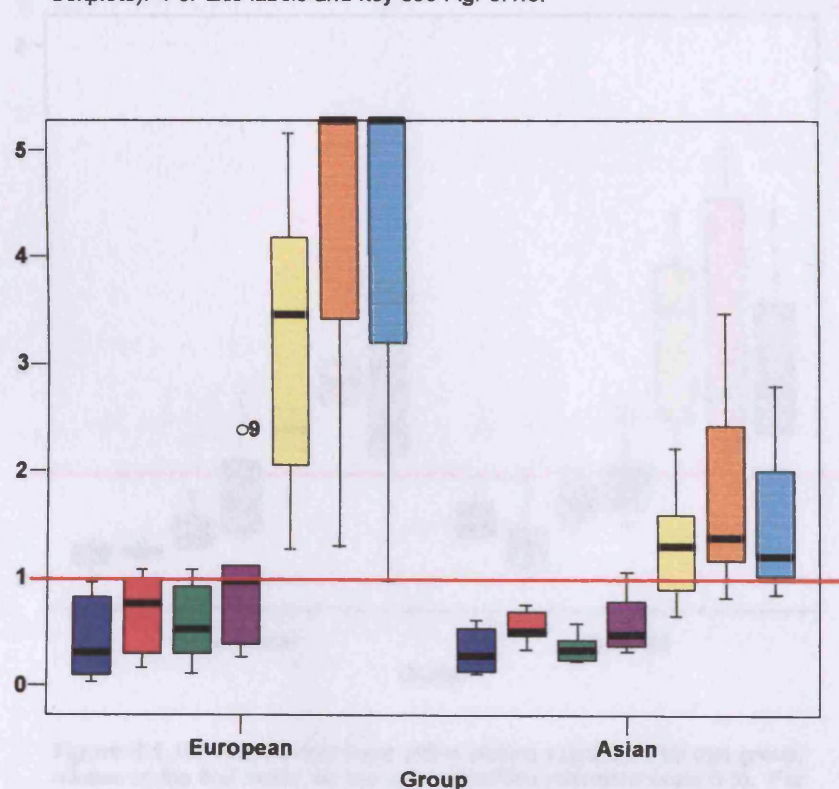


Figure 8.1.9: Neanderthal wear ratios plotted separately by region, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

Neanderthal age groups compared (Figs. 8.1.10-8.1.12)

It was considered possible that increasing age might have an effect on the wear pattern. For this reason the Neanderthal group was divided into two age groups, 25 or under and over 25 (Table 8.1.1). These two age categories were selected because specimens can be easily placed into either group based on the state of eruption of the third molars and the fusing of the epiphyses in the skeleton, which made it more likely that the descriptions in the published literature would be consistent. Where age estimations were not found in the literature, specimens were assigned an age category based up the eruption of the third molar and amount of tooth wear visible on the occlusal surface. Contrasting patterns of wear are found in the upper teeth. In the 25 and under group, the incisors show slightly higher median wear ratios, while the upper canines have a higher median wear ratio in the over 25 group, with a larger inter-quartile range. In addition, the premolars from the over 25 group have higher median wear ratios between 0.7 and 1, and the third molar has a higher median wear ratio with some individuals possessing similar wear ratios to the first molars from the same jaw.

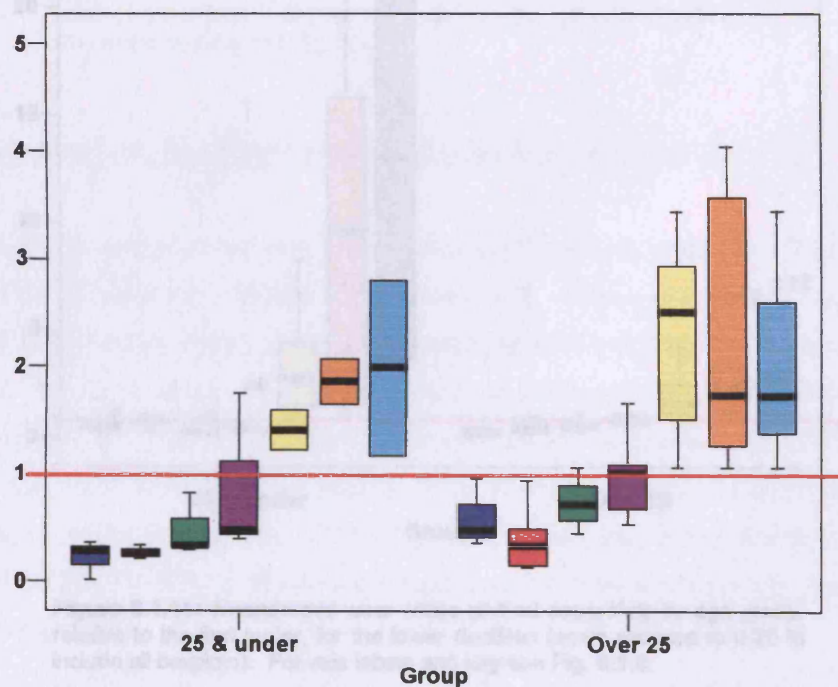


Figure 8.1.10: Neanderthal wear ratios plotted separately by age group, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In the lower dentition, there is much greater contrast between the two age groups. In the under 25 group, the anterior teeth show much higher median wear ratios and very greatly increased inter-quartile ranges. This is particularly apparent in the incisors. This heavy anterior wear pattern, relative to the first molar, results mostly from individuals from the site of Krapina who dominate the under 25 age group. Comparisons between the lower cheek teeth are hindered by the small number of wear ratios in the 25 and under age group, but some limited conclusions can be drawn. The median wear ratios for the premolars are higher in the over 25 group with larger inter-quartile ranges, while the second and third molars median wear ratios are higher in the 25 and under group.

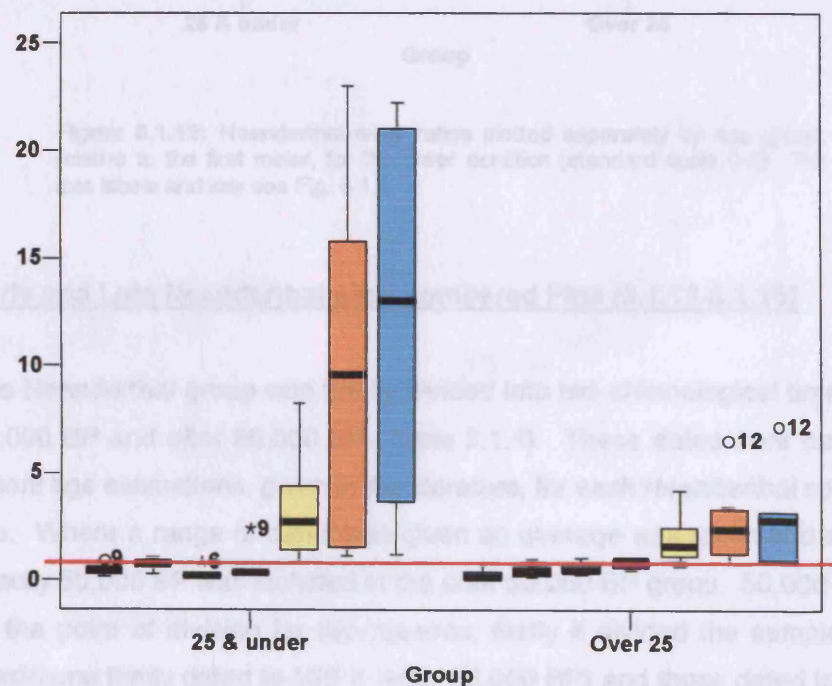


Figure 8.1.11: Neanderthal wear ratios plotted separately by age group, relative to the first molar, for the lower dentition (scale reduced to 0-25 to include all boxplots). For axis labels and key see Fig. 8.1.6.

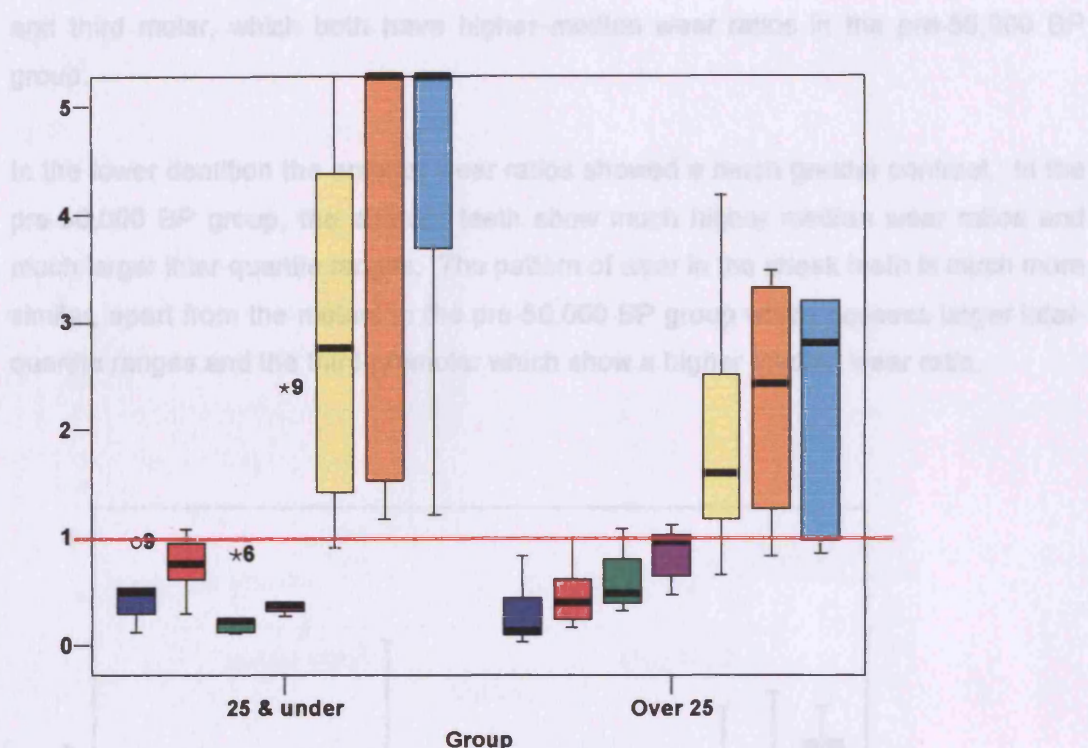


Figure 8.1.12: Neanderthal wear ratios plotted separately by age group, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

Early and Late Neanderthal sites compared Figs (8.1.13-8.1.15)

The Neanderthal group was finally divided into two chronological time periods: before 50,000 BP and after 50,000 BP (Table 8.1.1). These dates were based on the most recent age estimations, given in the literature, for each Neanderthal specimen and their site. Where a range of dates was given an average was taken and any site dating to exactly 50,000 BP was included in the after 50,000 BP group. 50,000 BP was selected as the point of division for two reasons; firstly it divided the sample between those specimens firmly dated to MIS 3 (after 50,000 BP) and those dated to before this time (before 50,000 BP); and secondly it divided the Neanderthals into two almost equally sized groups.

Contrasting patterns of wear were found in the upper teeth. In the post-50,000 BP group, the incisors showed higher median wear ratios with a larger inter-quartile range for the first incisor. The canine median wear ratio, however, is higher in the group dating pre-50,000 BP and possesses a slightly larger inter-quartile range. The upper cheek teeth show more similar wear pattern, with the exception of the third premolar

and third molar, which both have higher median wear ratios in the pre-50,000 BP group.

In the lower dentition the anterior wear ratios showed a much greater contrast. In the pre-50,000 BP group, the anterior teeth show much higher median wear ratios and much larger inter-quartile ranges. The pattern of wear in the cheek teeth is much more similar, apart from the molars in the pre-50,000 BP group which possess larger inter-quartile ranges and the third premolar which show a higher median wear ratio.

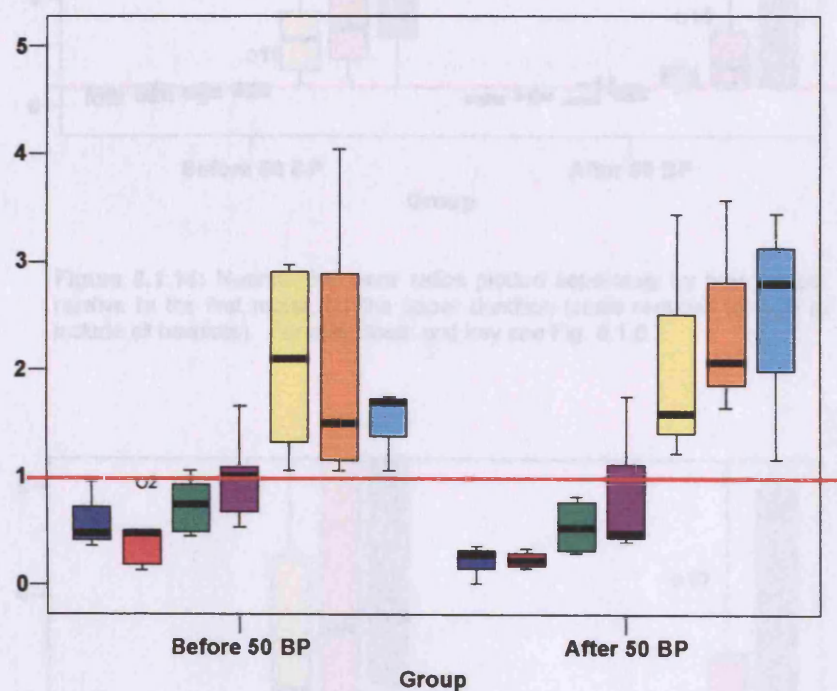


Figure 8.1.13: Neanderthal wear ratios plotted separately by time period, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

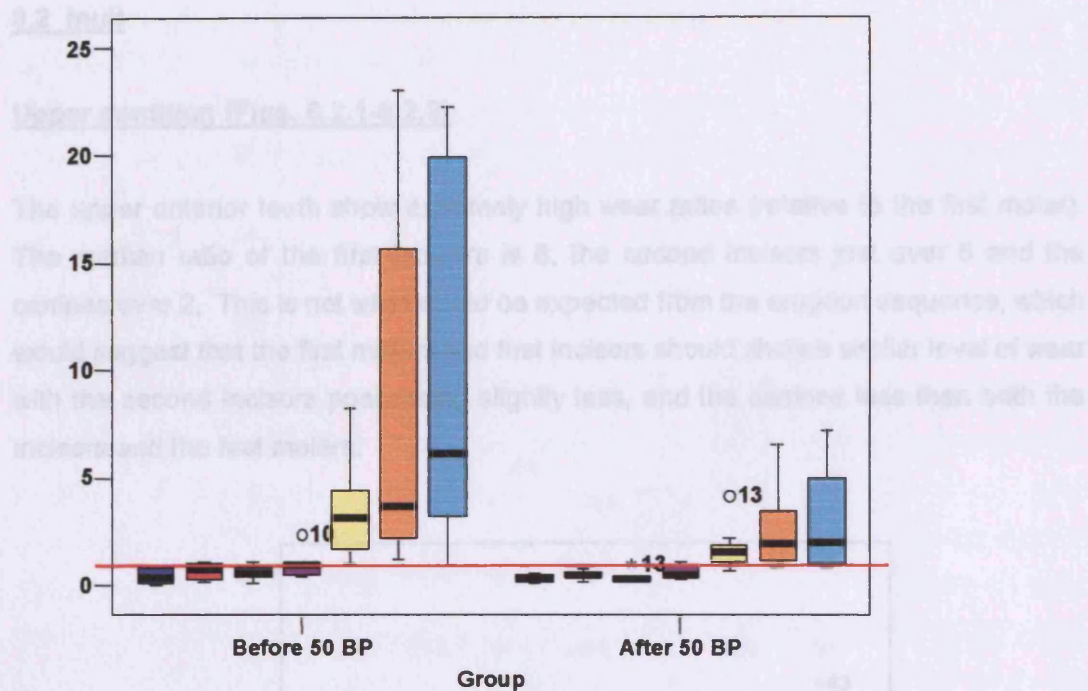


Figure 8.1.14: Neanderthal wear ratios plotted separately by time period, relative to the first molar, for the upper dentition (scale reduced to 0-25 to include all boxplots). For axis labels and key see Fig. 8.1.6.

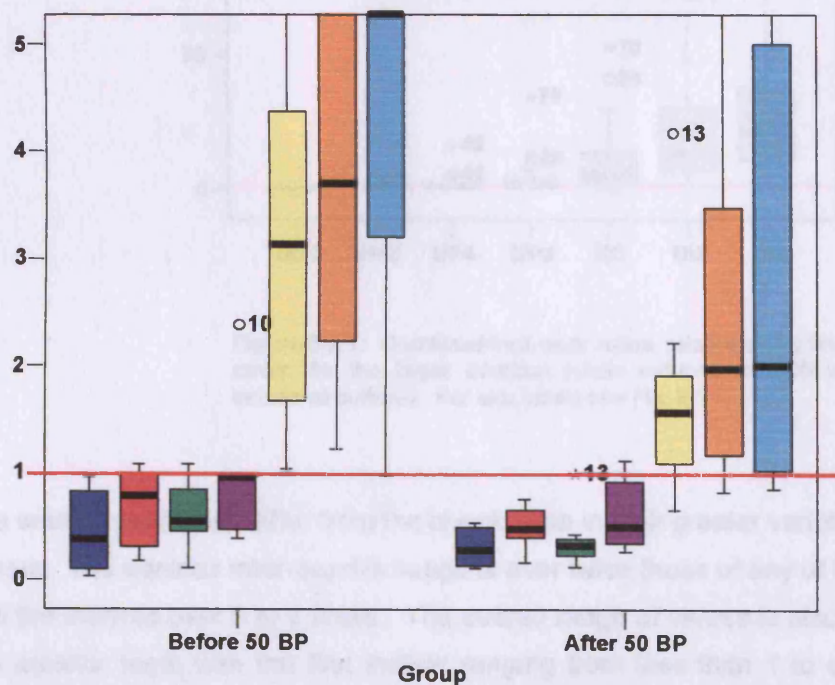


Figure 8.1.15: Neanderthal wear ratios plotted separately by time period, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

8.2 Inuit

Upper dentition (Figs. 8.2.1-8.2.3)

The upper anterior teeth show extremely high wear ratios (relative to the first molar). The median ratio of the first incisors is 8, the second incisors just over 5 and the canines over 2. This is not what would be expected from the eruption sequence, which would suggest that the first molars and first incisors should show a similar level of wear with the second incisors possessing slightly less, and the canines less than both the incisors and the first molars.

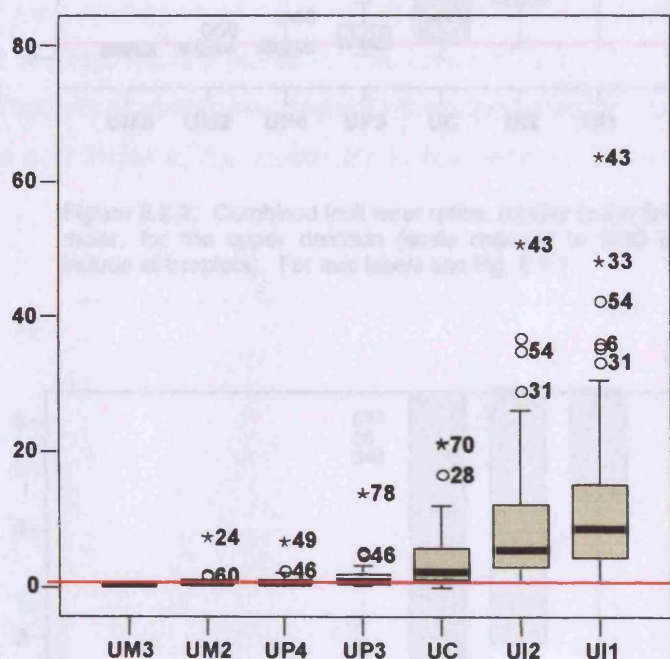


Figure 8.2.1: Combined Inuit wear ratios, relative to the first molar, for the upper dentition (scale reduced to 0-80 to include all outliers). For axis labels see Fig. 8.1.1.

The anterior teeth also differ from the cheek teeth in their greater variation of wear ratio values. The canines inter-quartile range is over twice those of any of the cheek teeth, and the incisors over 6 to 7 times. The overall range of values is also much higher in the anterior teeth with the first incisor ranging from less than 1 to over 30 and the second incisors from less than 1 to over 25.

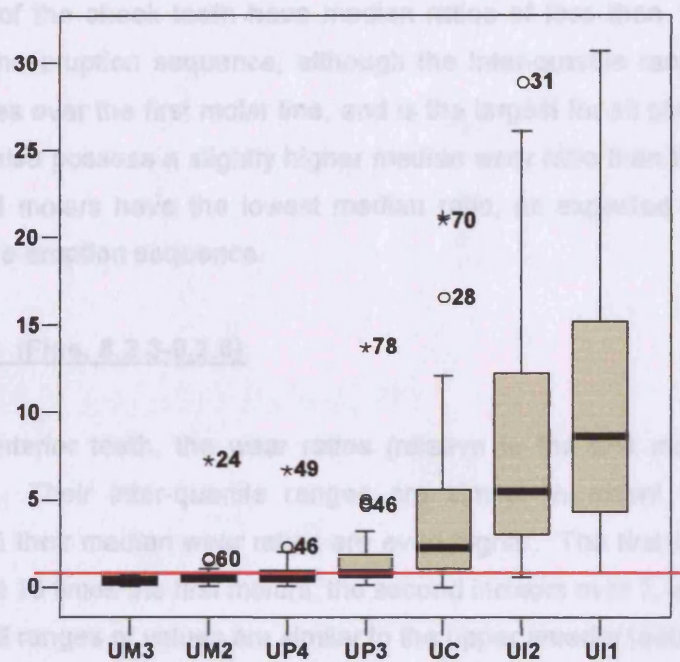


Figure 8.2.2: Combined Inuit wear ratios, relative to the first molar, for the upper dentition (scale reduced to 0-30 to include all boxplots). For axis labels see Fig. 8.1.1.

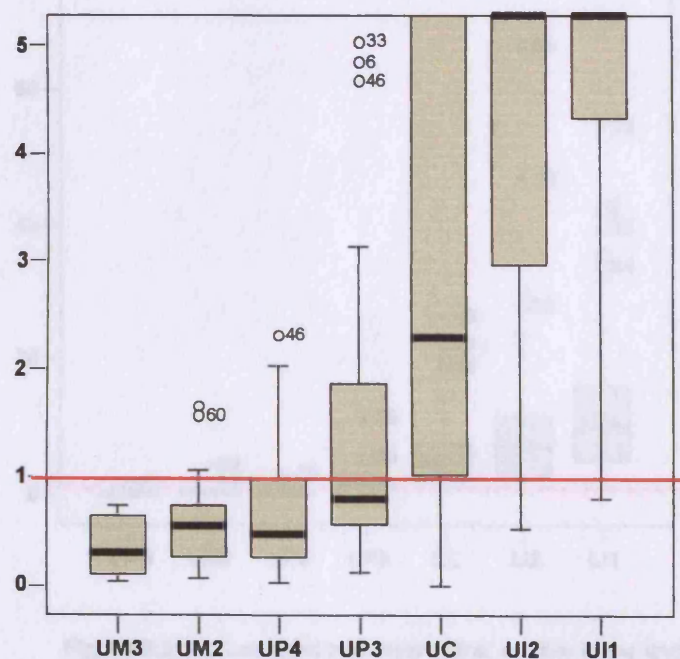


Figure 8.2.3: Combined Inuit wear ratios, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

By contrast, all of the cheek teeth have median ratios of less than 1, as would be expected from the eruption sequence, although the inter-quartile range of the third premolars crosses over the first molar line, and is the largest for all cheek teeth. The third premolars also possess a slightly higher median wear ratio than the other cheek teeth. The third molars have the lowest median ratio, as expected from their late position within the eruption sequence.

Lower dentition (Figs. 8.2.3-8.2.6)

For the lower anterior teeth, the wear ratios (relative to the first molar) are again extremely high. Their inter-quartile ranges are similar in extent to their upper counterparts, but their median wear ratios are even higher. The first incisors have a median of almost 10 times the first molars, the second incisors over 7, and the canines almost 5. Overall ranges of values are similar to the upper anterior teeth, from under 1 to over 30 in the first incisors, just under 25 in the second incisors and 15 in the canines.

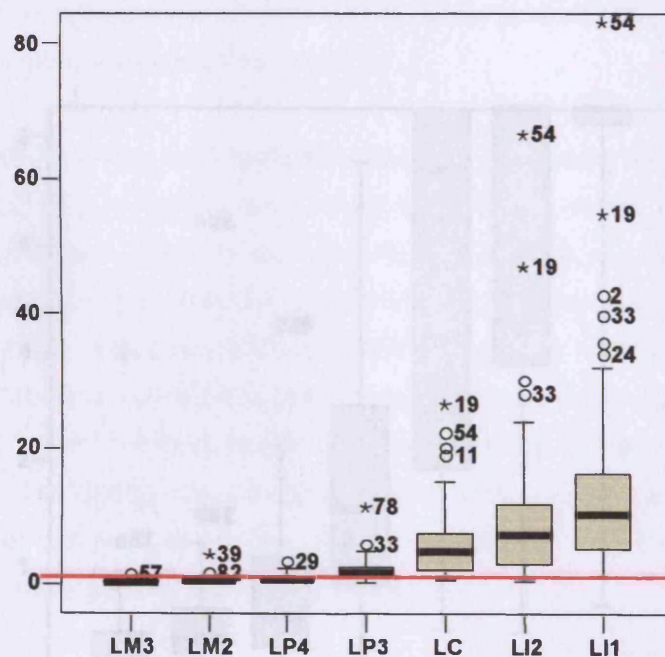


Figure 8.2.4: Combined Inuit wear ratios, relative to the first molar, for the lower dentition (scale reduced to 0-80 to include all outliers). For axis labels see Fig. 8.1.1.

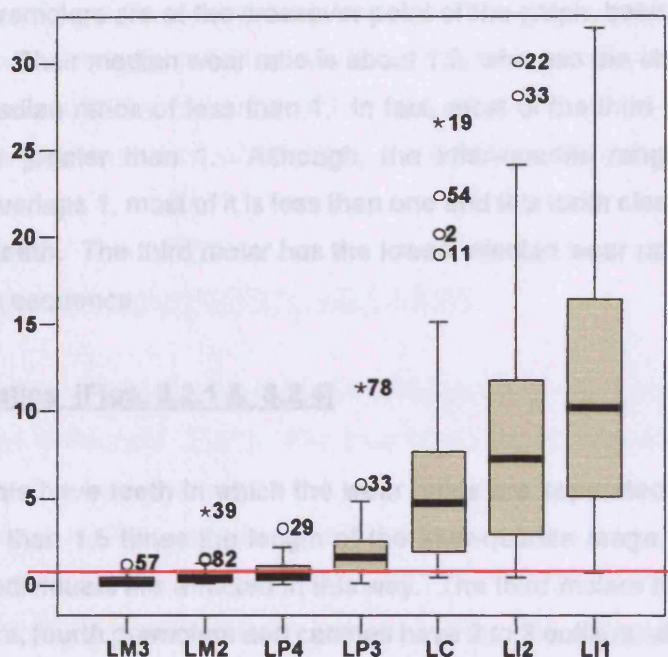


Figure 8.2.5: Combined Inuit wear ratios, relative to the first molar, for the lower dentition (scale reduced to 0-30 to include all boxplots). For axis labels see Fig. 8.1.1.

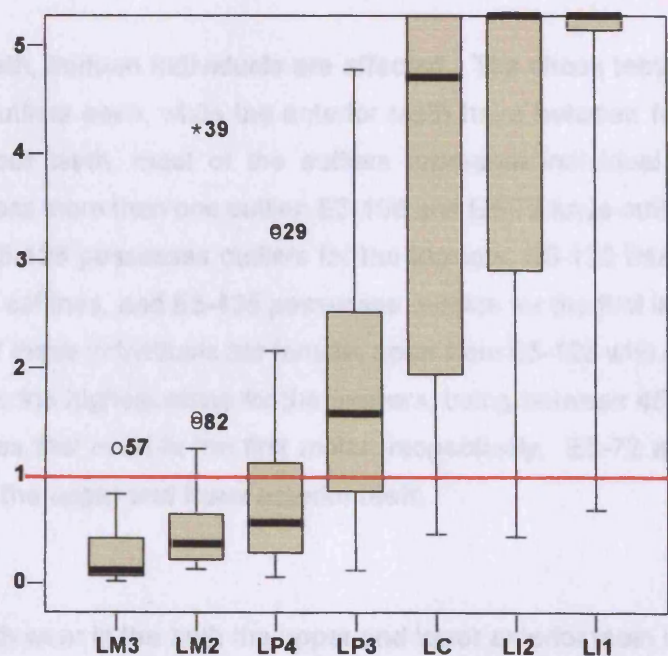


Figure 8.2.6: Combined Inuit wear ratios, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

The lower third premolars are at the crossover point of the graph, between the anterior and cheek teeth. Their median wear ratio is about 1.5, whereas the other lower cheek teeth all have median ratios of less than 1. In fact, most of the third premolars inter-quartile range is greater than 1. Although, the inter-quartile range of the fourth premolars also overlaps 1, most of it is less than one and this tooth clearly belongs with the other cheek teeth. The third molar has the lowest median wear ratio, as expected from the eruption sequence.

Outlying wear ratios (Figs. 8.2.1 & 8.2.4)

Several individuals have teeth in which the wear ratios are separated from the upper quartile by more than 1.5 times the length of the inter-quartile range. For the upper teeth, fourteen individuals are affected in this way. The third molars have no outliers; the second molars, fourth premolars and canines have 2 to 3 outliers, while the incisors and third premolars have between 4 and 6 each. In most cases it is only a single tooth per individual that is affected, but in E5-578 both premolars are affected, and both incisors in E5-72, E5-427, E5-435 and E5-549. All five of these individuals are female. E5-549 showed the highest wear ratios for the incisors, between 50 and 60 times that seen in the first molars from the same jaw.

For the lower teeth, thirteen individuals are affected. The cheek teeth have between one and three outliers each, while the anterior teeth have between four and six. As seen in the upper teeth, most of the outliers represent individual teeth, but five individuals possess more than one outlier: E3-156 and E5-72 have outliers for all of the anterior teeth; E5-125 possesses outliers for the incisors; E5-128 has outliers for the first incisors and canines, and E5-435 possesses outliers for the first incisors and third premolars. All of these individuals are female, apart from E5-128 who is male. E3-156 and E5-72 shows the highest ratios for the incisors, being between 45 and 55, and 65 and over 80 times that seen in the first molar, respectively. E5-72 and E5-435 both have outliers for the upper and lower anterior teeth.

Summary

In summary, tooth wear in the both the upper and lower anterior teeth is much greater, relative to the first molars, than would be expected from the eruption sequence and more variable than the rest of the dentition. Tooth wear in the upper and lower molars follow more the pattern expected from eruption, with less wear than the first molar and smaller ranges in wear ratios. Most of the upper premolars are less worn than the first

molars, as expected from the eruption sequence, but the inter-quartile range of the third premolar does overlap the first molar line. The lower third premolars show a higher median wear ratio than the rest of the lower cheek teeth and a larger inter-quartile range placing them in an intermediate position between the cheek teeth and the anterior teeth.

Male and Female Inuit compared (Figs. 8.2.7-8.2.10)

Differences in tooth use between males and females have often been reported for recent Inuit groups (Pedersen, 1947). The Inuit from Igloodik were therefore divided into male and female groups, based on the sex recorded at the time the impressions were taken (Table 8.2.1). In the upper dentition, there is a strong contrast between the males and females. In the female group, the anterior teeth show much higher median wear ratios and increased inter-quartile ranges. The third premolars are at the crossover point of the graph between the anterior and cheek teeth in the female group, with a median wear ratio of just over 1 and a much larger inter-quartile range than the other cheek teeth. In the males this tooth has a median wear ratio of about 0.5 and fits better within the wear ratio pattern of the other cheek teeth. The third molars also have a higher median wear ration in the female group.

Number of specimens	Sex		Age Category (years)				
	Male	Female	21-30	31-40	41-50	51-60	60 +
Igloodik	40	46	18	34	16	15	3

Table 8.2.1: Inuit specimens included in the current study, divided by sex and age. These divisions are based on information recorded at the time the dental impressions were taken.

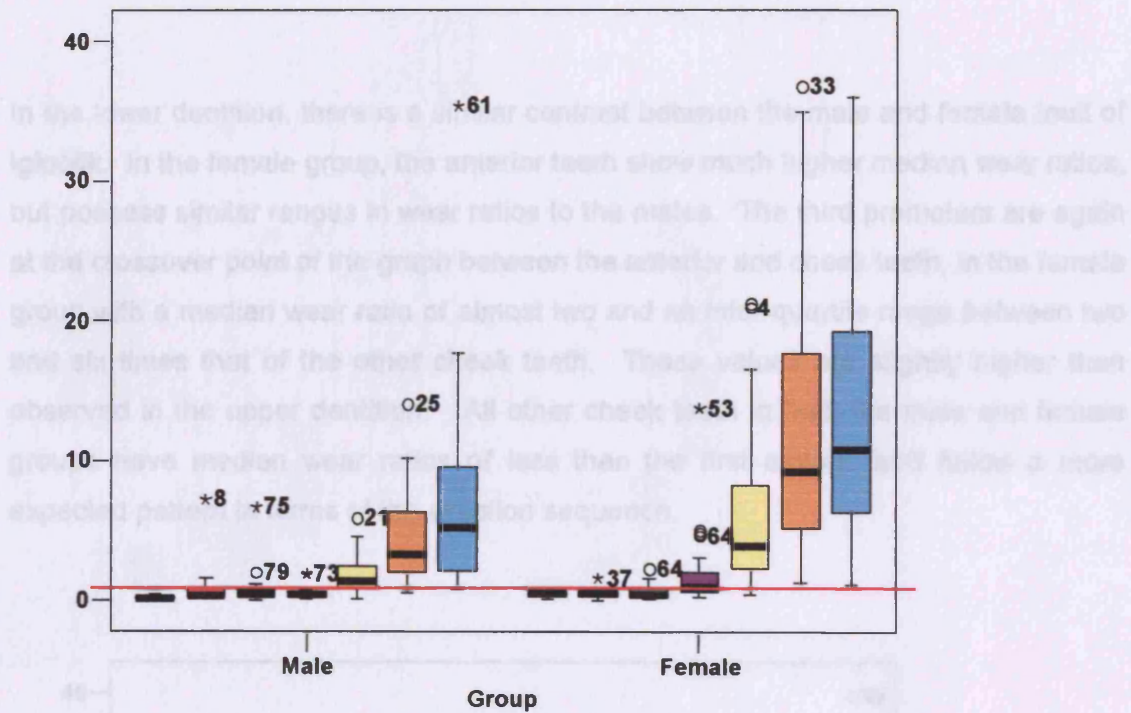


Figure 8.2.7: Male and female Inuit wear ratios plotted separately, relative to the first molar, for the upper dentition (scale reduced to 0-40 to include all boxplots). For axis labels and key see Fig. 8.1.6.

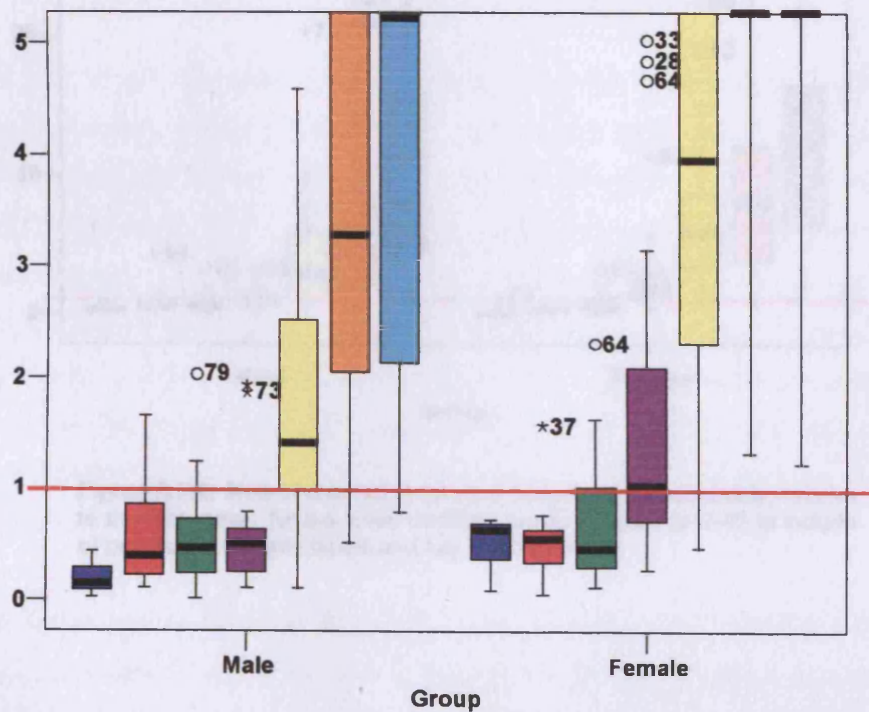


Figure 8.2.8: Male and female Inuit wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In the lower dentition, there is a similar contrast between the male and female Inuit of Igloodlik. In the female group, the anterior teeth show much higher median wear ratios, but possess similar ranges in wear ratios to the males. The third premolars are again at the crossover point of the graph between the anterior and cheek teeth, in the female group with a median wear ratio of almost two and an inter-quartile range between two and six times that of the other cheek teeth. These values are slightly higher than observed in the upper dentition. All other cheek teeth in both the male and female groups have median wear ratios of less than the first molars, and follow a more expected pattern in terms of the eruption sequence.

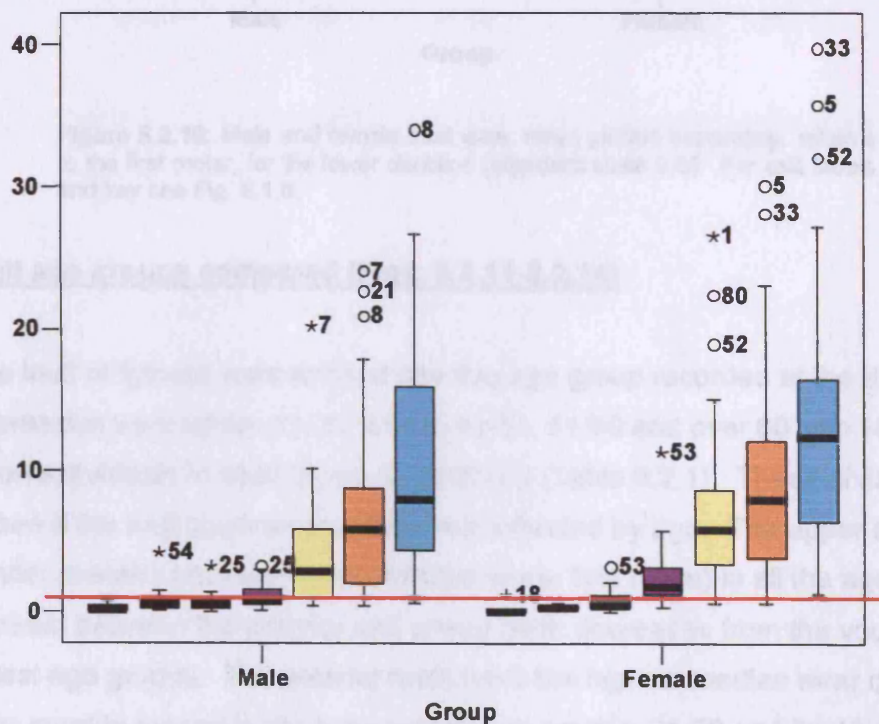


Figure 8.2.9: Male and female Inuit wear ratios plotted separately, relative to the first molar, for the lower dentition (scale reduced to 0-40 to include all boxplots). For axis labels and key see Fig. 8.1.6.

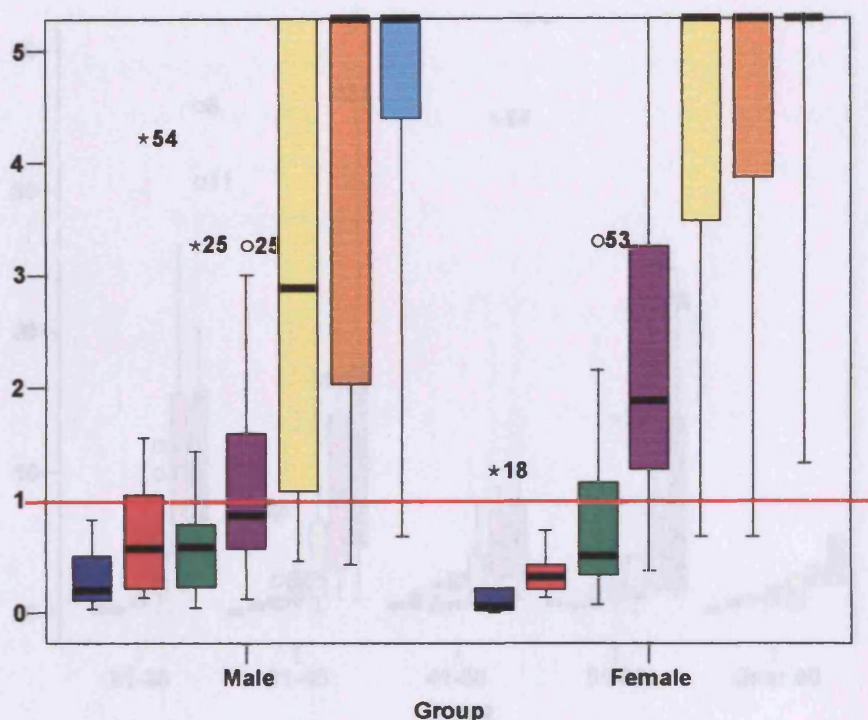


Figure 8.2.10: Male and female Inuit wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

Inuit age groups compared (Figs. 8.2.11-8.2.14)

The Inuit of Igloodik were divided into five age group recorded at the time the impression were taken; 21-30, 31-40, 41-50, 51-60 and over 60 with 18, 34, 16, 15 and three individuals in each group respectively (Table 8.2.1). These divisions were made to see if the Inuit tooth wear pattern was affected by age. The upper dentitions show similar overall patterns of wear (relative to the first molar) in all the age groups, but the contrast between the anterior and cheek teeth decreases from the youngest to the oldest age groups. The anterior teeth have the highest median wear ratios and largest inter-quartile ranges in the two younger age groups, 21-30 and 31-40 and the lowest in the over 60s, although the small number of wear ratios in this group limits the conclusions that can be drawn.

The upper cheek teeth show similar wear patterns throughout the five age groups. Fourth premolars mostly have the highest median wear ratios, with the 31-40, 51-60 and over 60s possessing the higher medians and largest inter-quartile ranges.

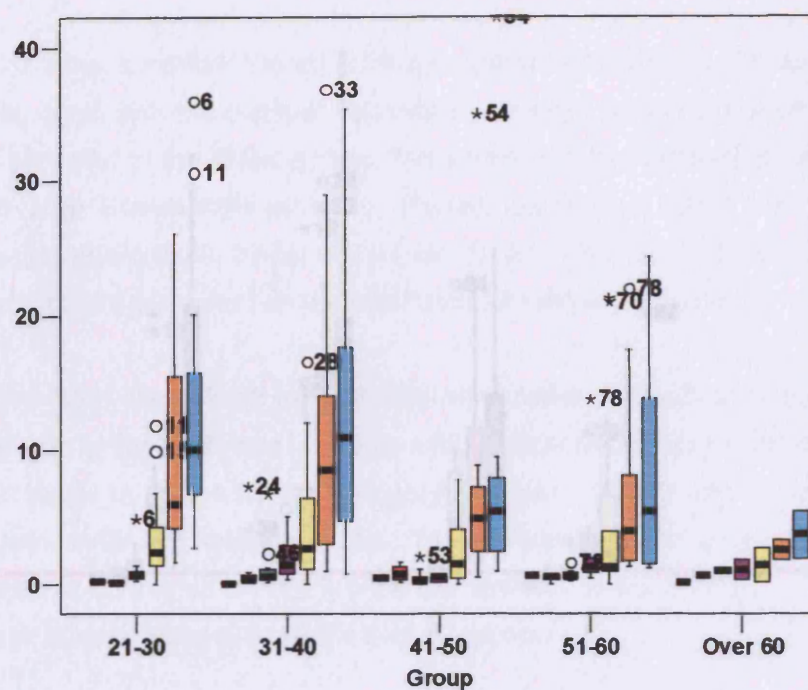


Figure 8.2.11: Inuit age group wear ratios plotted separately, relative to the first molar, for the upper dentition (scale reduced to 0-40 to include all boxplots). For axis labels and key see Fig. 8.1.6.

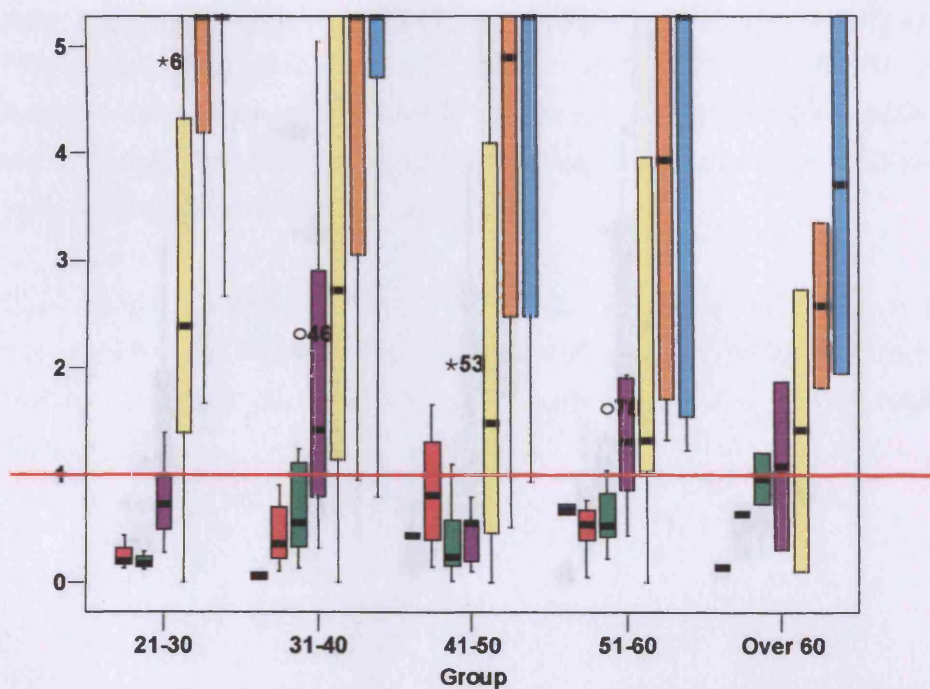


Figure 8.2.12: Inuit age group wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

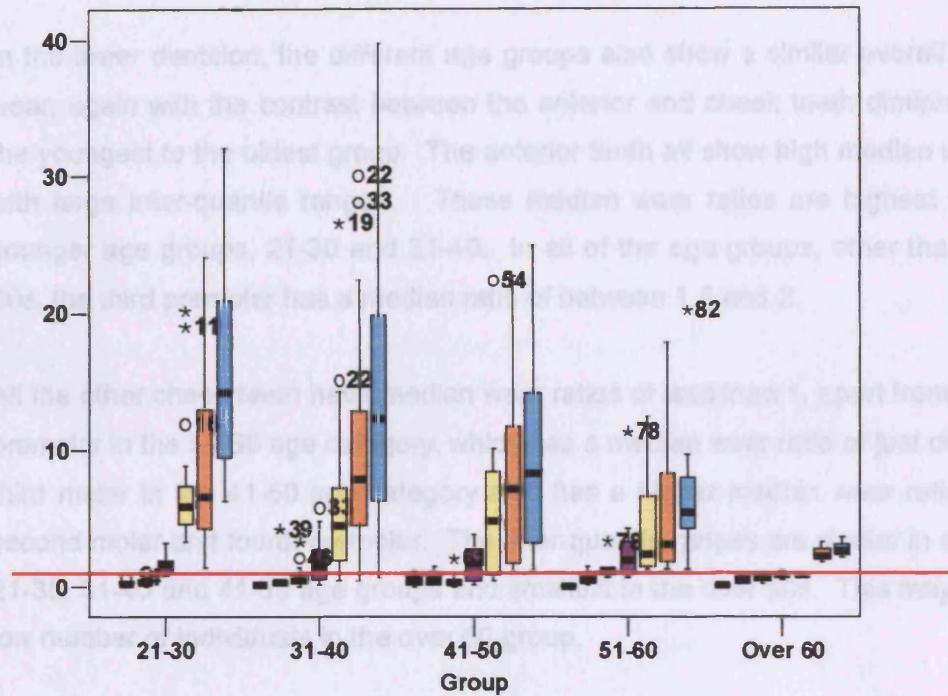


Figure 8.2.13: Inuit age group wear ratios plotted separately, relative to the first molar, for the lower dentition (scale reduced to 0-40 to include all boxplots). For axis labels and key see Fig. 8.1.6.

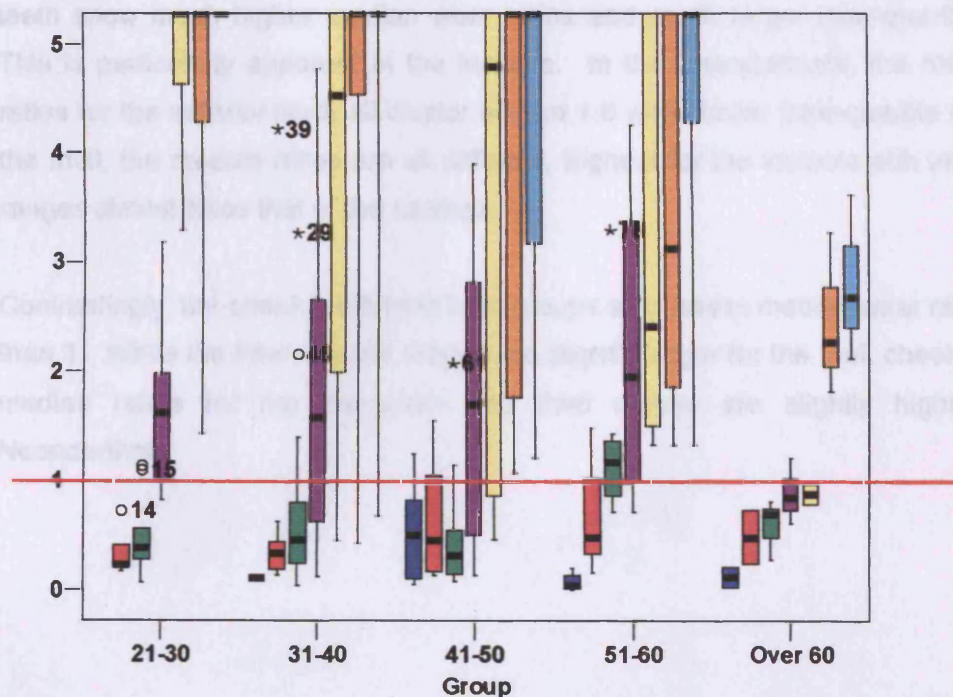


Figure 8.2.14: Inuit age group wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In the lower dentition, the different age groups also show a similar overall pattern of wear, again with the contrast between the anterior and cheek teeth diminishing from the youngest to the oldest group. The anterior teeth all show high median wear ratios with large inter-quartile ranges. These median wear ratios are highest in the two younger age groups, 21-30 and 31-40. In all of the age groups, other than the over 60s, the third premolar has a median ratio of between 1.5 and 2.

All the other cheek teeth have median wear ratios of less than 1, apart from the fourth premolar in the 51-60 age category, which has a median wear ratio of just over 1. The third molar in the 41-50 age category also has a higher median wear ratio than the second molar and fourth premolar. The inter-quartile ranges are similar in size for the 21-30, 31-40 and 41-50 age groups and smallest in the over 60s. This may be due to low number of individuals in the over 60 group.

Inuit and Neanderthals compared (Figs. 8.2.15-8.2.18)

In the Upper dentition, there is a strong contrast between the wear patterns (relative to the first molar) of the Neanderthals and Inuit of Igloodik. In the Inuit, the upper anterior teeth show much higher median wear ratios and much larger inter-quartile ranges. This is particularly apparent in the incisors. In the Neanderthals, the median wear ratios for the anterior teeth all cluster around 1.6 with similar inter-quartile ranges. In the Inuit, the median ratios are all different, highest for the incisors with inter-quartile ranges almost twice that of the canines.

Contrastingly, the cheek teeth from both groups all possess median wear ratios of less than 1. While the inter-quartile ranges are slightly larger for the Inuit cheek teeth, the median ratios for the premolars and third molars are slightly higher for the Neanderthals.

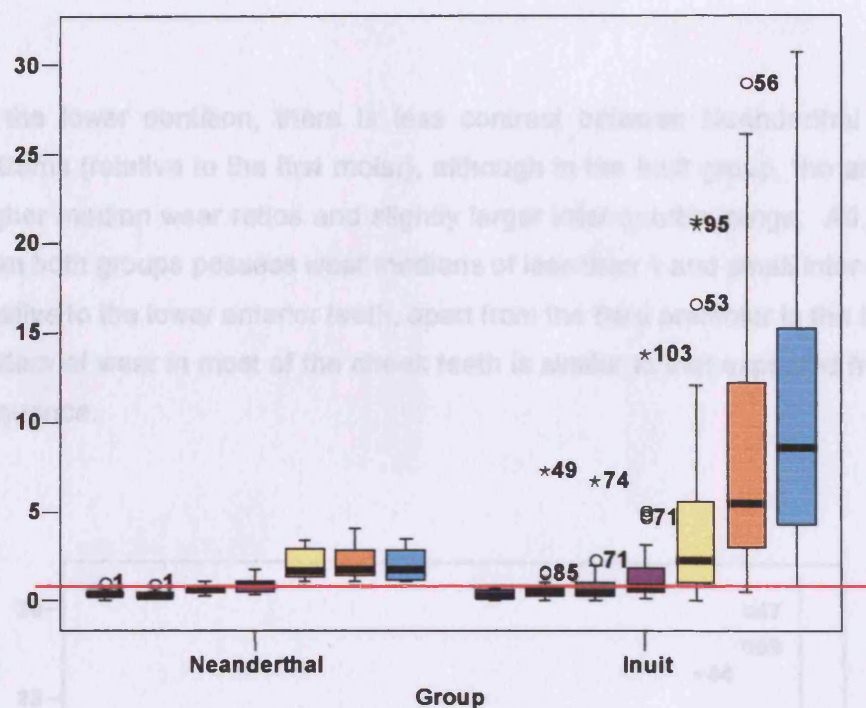


Figure 8.2.15: Neanderthal and Inuit wear ratios plotted separately, relative to the first molar, for the upper dentition (scale reduced to 0-30 to include all boxplots). For axis labels and key see Fig. 8.1.6.

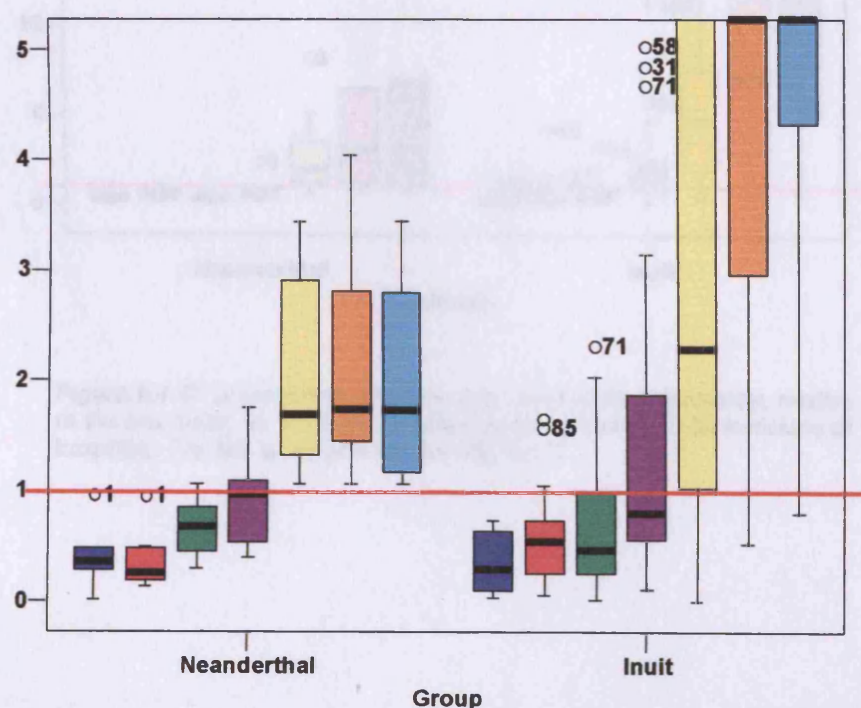


Figure 8.2.16: Neanderthal and Inuit wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In the lower dentition, there is less contrast between Neanderthal and Inuit wear patterns (relative to the first molar), although in the Inuit group, the anterior still show higher median wear ratios and slightly larger inter-quartile range. All the cheek teeth from both groups possess wear medians of less than 1 and small inter-quartile ranges, relative to the lower anterior teeth, apart from the third premolar in the Inuit group. The pattern of wear in most of the cheek teeth is similar to that expected from the eruption sequence.

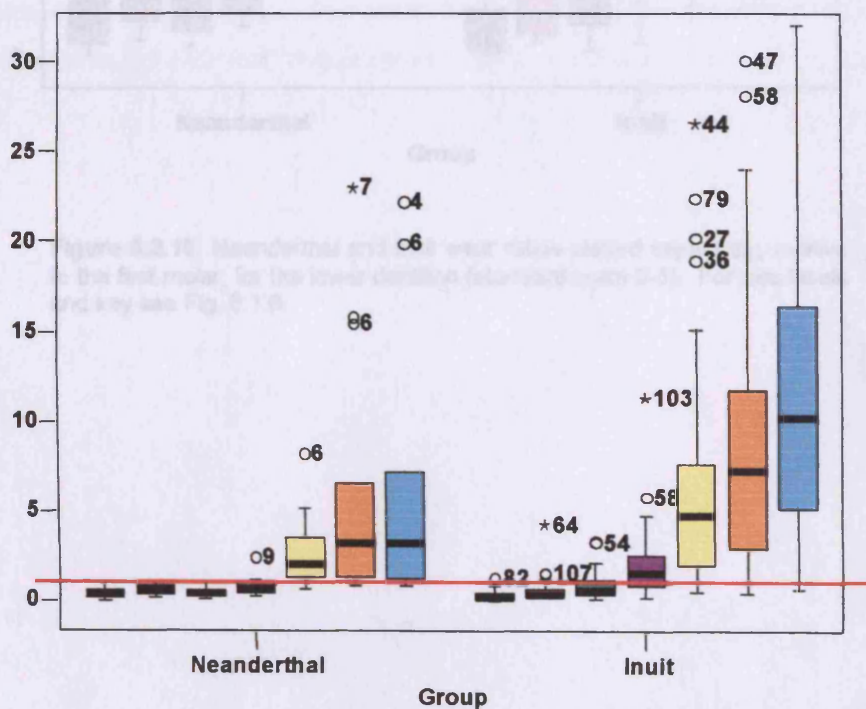


Figure 8.2.17: Neanderthal and Inuit wear ratios plotted separately, relative to the first molar, for the lower dentition (scale reduced to 0-30 to include all boxplots). For axis labels and key see Fig. 8.1.6.

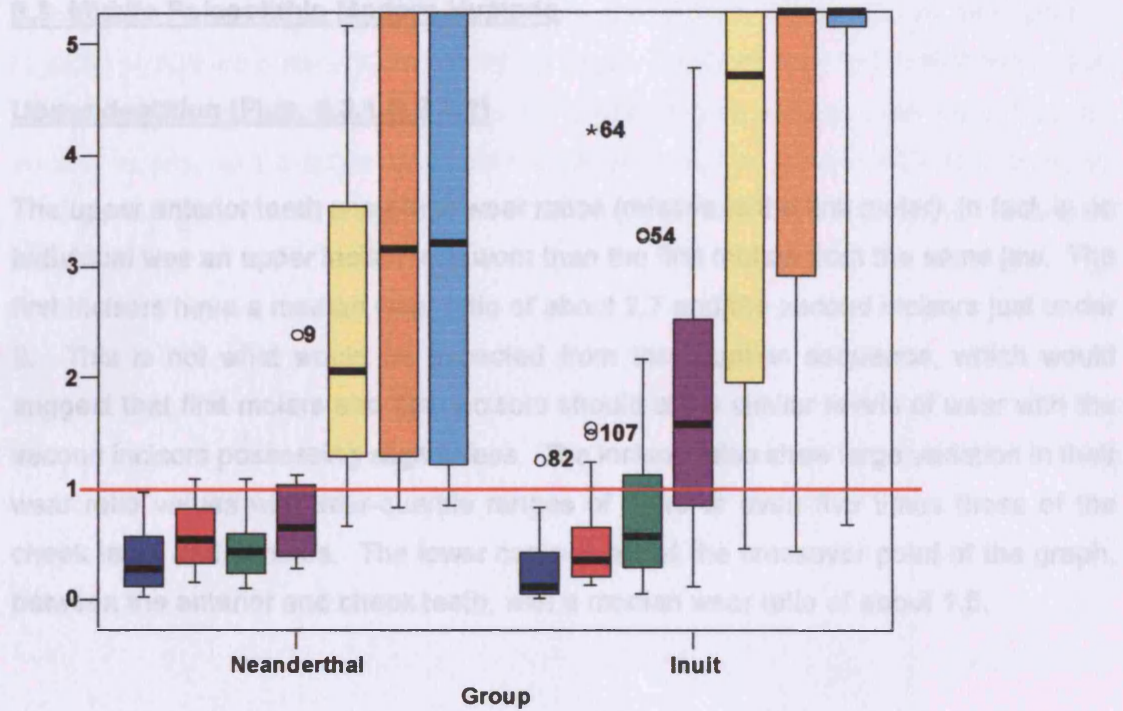


Figure 8.2.18: Neanderthal and Inuit wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

8.3 Middle Palaeolithic Modern Humans

Upper dentition (Figs. 8.3.1 & 8.3.2)

The upper anterior teeth show high wear ratios (relative to the first molar). In fact, in no individual was an upper incisor less worn than the first molars from the same jaw. The first incisors have a median wear ratio of about 2.7 and the second incisors just under 2. This is not what would be expected from the eruption sequence, which would suggest that first molars and first incisors should show similar levels of wear with the second incisors possessing slightly less. The incisors also show large variation in their wear ratio values with inter-quartile ranges of three or even five times those of the cheek teeth and canines. The incisors also show large variation in their wear ratio values with inter-quartile ranges of three or even five times those of the cheek teeth and canines. The lower canines are at the crossover point of the graph, between the anterior and cheek teeth, with a median wear ratio of about 1.5.

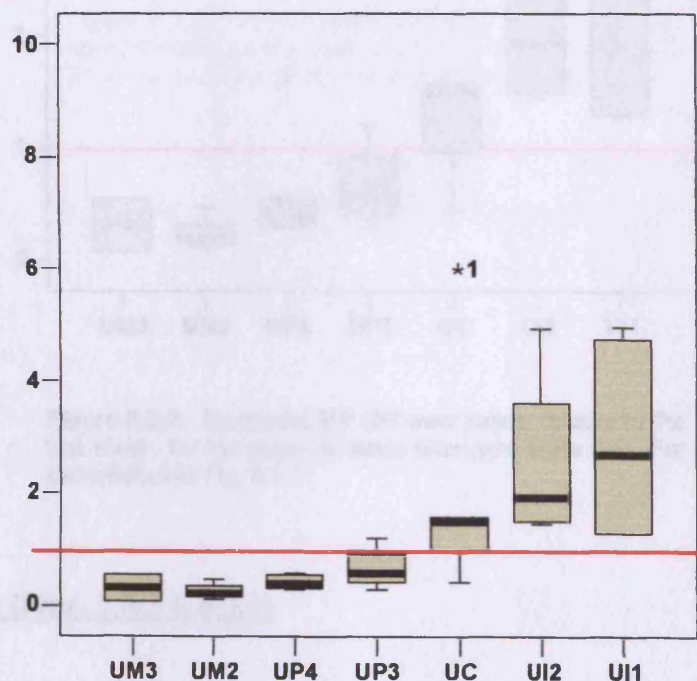


Figure 8.3.1: Combined MP MH wear ratios, relative to the first molar, for the upper dentition (scale reduced to 0-10 to include all outliers). For axis labels see Fig. 8.1.1.

The upper cheek teeth all have median wear ratios of less than one. In fact, none of their inter-quartile ranges rises above 1. The third premolars have a slightly higher median wear ratio than the fourth premolars and second molars with a larger inter-

quartile range. In terms of eruption sequence, these three teeth would all be expected to show similar wear patterns, with slightly higher levels of wear in the first molar and first incisor. The third molars also have a slightly higher median wear ratio than the second molars and a larger inter-quartile range than the second molars and fourth premolars. Their late eruption means they would be expected to possess the lowest wear ratios.

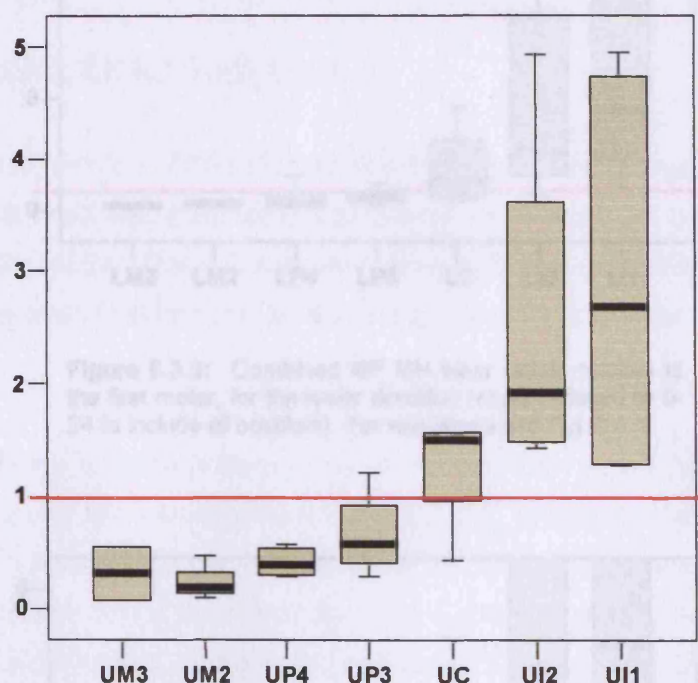
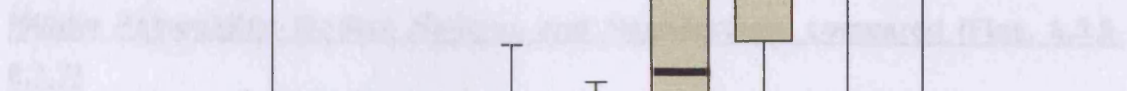


Figure 8.3.2: Combined MP MH wear ratios, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

Lower dentition (Figs. 8.3.3 & 8.3.4)

For the lower incisors, the median wear ratios (relative to the first molar) are higher than those for the upper incisors, with much larger inter-quartile ranges. The lower first incisor median wear ratio is about 4.5 and the second incisor 2.5, with some individuals having wear ratios between 15 and 20 times that of the first molar levels from the same jaw. In terms of eruption sequence, the first incisors would be expected to possess similar wear ratios to that of the first molars and the second incisors slightly less.

Group	Mean Number of Correct Responses	Standard Error (SE)
Control (n=10)	~3.2	~0.8
Low (n=10)	~4.6	~0.1
High (n=10)	~4.7	~0.1



Network Type	Min	Q1	Median	Q3	Max
LM3	2	3	4	5	6
LM2	4	4	5	6	7
LP4	2	3	4	6	7
LP3	4	5	6	7	8
LC	7	7	8	9	10
LI2	0	0	0	0	0
LI1	0	0	0	0	0

The lower canines are also at the crossover point of the graph, between the anterior and cheek teeth with a slightly lower median wear ratio than their upper counterparts, just above 1, and a much larger inter-quartile range. All of the cheek have median wear ratios and inter-quartile ranges of less than one and while the canines inter-quartile range does overlap with those of the premolars the tooth clearly belongs with the other anterior teeth in terms of its wear state. The cheek teeth all have similar median wear ratios, with the third premolar being the highest and the premolars possessing larger inter-quartiles ranges than the molars.

Outlying wear ratios (Figs. 8.3.1 & 8.3.3)

Only one individual from the Middle Palaeolithic Modern Human group has a tooth with a wear ratio that is separated from the upper quartile by more than 1.5 times the length of the inter-quartile range. This is the upper canine of Qafzeh 5 (outlier 1) whose wear ratio was over six times that seen in the first molar from the same jaw.

Summary

In summary, tooth wear in the anterior teeth is heavier than would be expected from the eruption sequence and more variable in the incisors, relative to the first molar, than the rest of the dentition. The wear ratios in the lower incisors are even higher and more varied than their upper counterparts. The upper and lower canines are at the cross over point of the graph, between the anterior and cheek teeth, with median wear ratios just above the first molar line. The pattern of tooth wear in the upper and lower cheek teeth is more similar to that expected from the eruption sequence and less variable relative to the first molar, with the third premolar showing the highest median wear ratio and largest inter-quartile range.

Middle Palaeolithic Modern Humans and Neanderthals compared (Figs. 8.3.5-8.3.7)

In the upper dentition, the pattern of wear ratios differs between the Neanderthals and Middle Palaeolithic Modern Humans. In the Middle Palaeolithic Modern Humans, the first incisors have a much higher median wear ratio of about 2.7 and a larger inter-quartile range. This difference is not so great in the second incisors with only a slighter higher median wear ratio and slightly larger inter-quartile range. The canines from both groups possess similar median wear ratios, but the inter-quartile range of the Middle Palaeolithic Modern Humans is over twice that of the Neanderthals. The

upper canines have similar wear ratios to the incisors in the Neanderthal group, while in the Middle Palaeolithic Modern Humans their wear ratios are much lower than the incisors. The cheek teeth more closely resemble the expected wear pattern from the eruption sequence in both the Neanderthals and Early Modern Humans. The third premolar has a higher median wear ratio in the Neanderthal group, of about 1. The third molars have higher median wear ratios than the second molars in both groups.

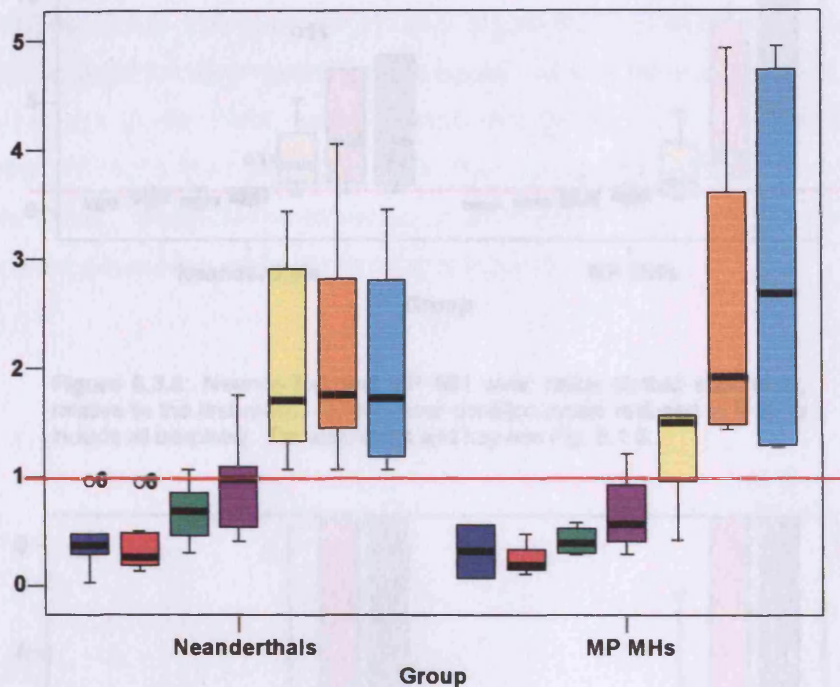


Figure 8.3.5: Neanderthal and MP MH wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In the lower dentition, there is a similar contrast between the Middle Palaeolithic Modern Humans and the Neanderthals. In the Middle Palaeolithic Modern Humans, the first incisors have a much higher median wear ratio and a larger inter-quartile range. The second incisors, however, have a slightly lower median wear ratio than that of the Neanderthals and a slightly larger inter-quartile range. In the Neanderthals, the lower canines show a higher median wear ratio and a similar inter-quartile range. This pattern of wear is more similar to that of the incisors than is seen in the Middle Palaeolithic Modern Human group. The lower cheek teeth from both groups possess median wear ratios more similar to that expected from the eruption sequence with smaller inter-quartile ranges than their upper counterparts.

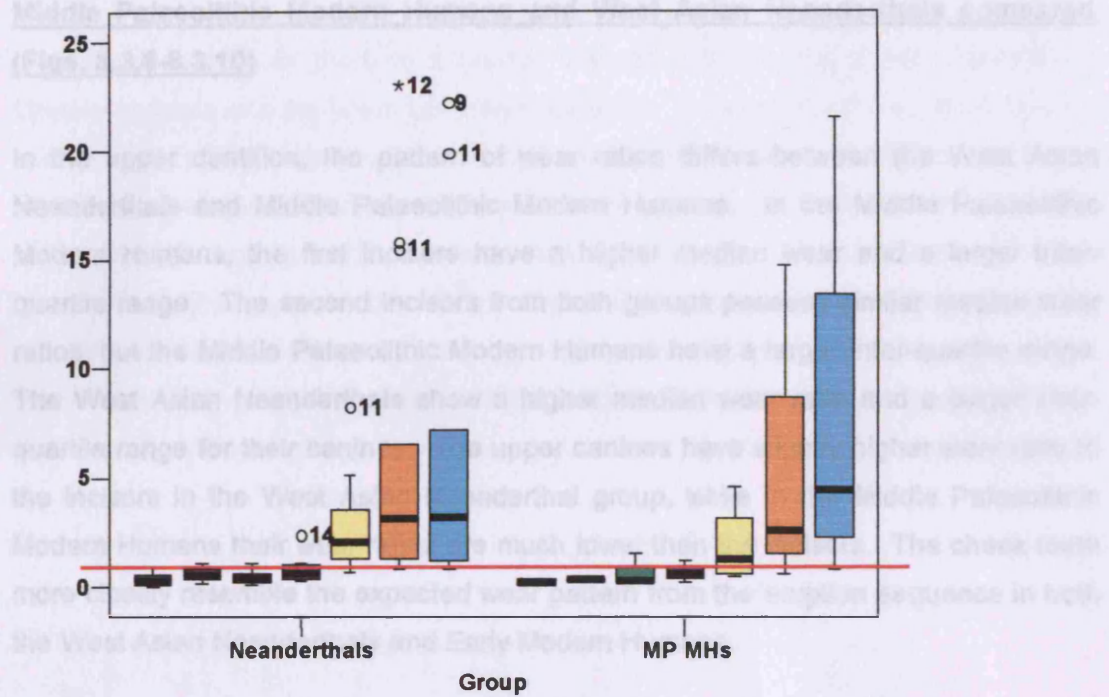


Figure 8.3.6: Neanderthal and MP MH wear ratios plotted separately, relative to the first molar, for the lower dentition (scale reduced to 0-30 to include all boxplots). For axis labels and key see Fig. 8.1.6.

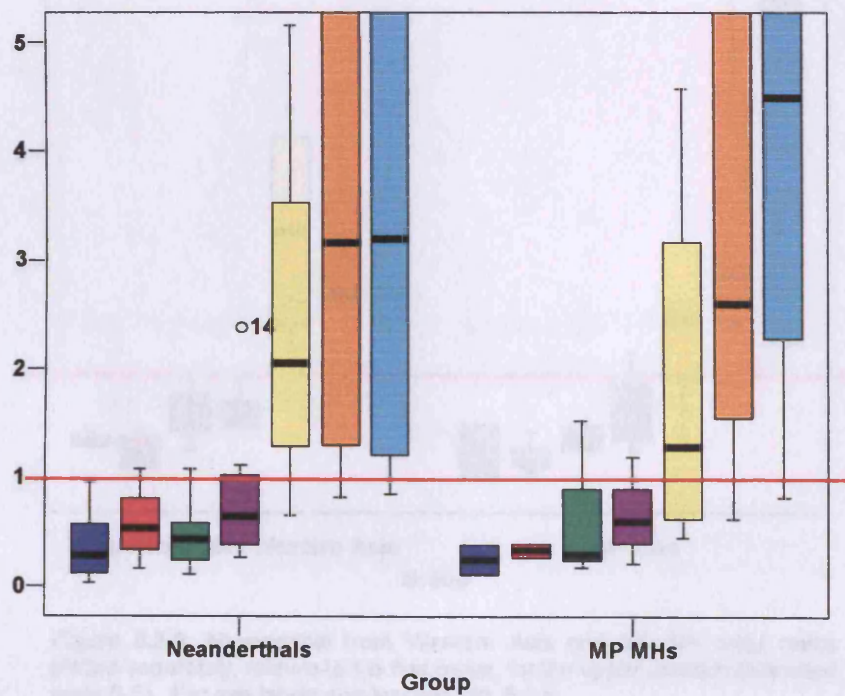


Figure 8.3.7: Neanderthal and MP MH wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

Middle Palaeolithic Modern Humans and West Asian Neanderthals compared
(Figs. 8.3.8-8.3.10)

In the upper dentition, the pattern of wear ratios differs between the West Asian Neanderthals and Middle Palaeolithic Modern Humans. In the Middle Palaeolithic Modern Humans, the first incisors have a higher median wear and a larger inter-quartile range. The second incisors from both groups possess similar median wear ratios, but the Middle Palaeolithic Modern Humans have a larger inter-quartile range. The West Asian Neanderthals show a higher median wear ratio and a larger inter-quartile range for their canines. The upper canines have slightly higher wear ratio to the incisors in the West Asian Neanderthal group, while in the Middle Palaeolithic Modern Humans their wear ratios are much lower than the incisors. The cheek teeth more closely resemble the expected wear pattern from the eruption sequence in both the West Asian Neanderthals and Early Modern Humans.

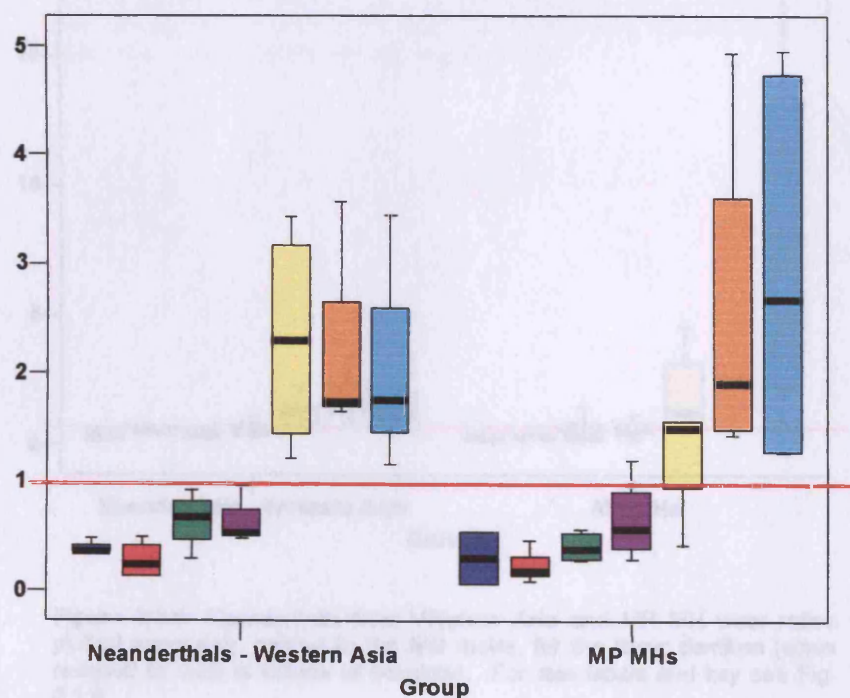


Figure 8.3.8: Neanderthal from Western Asia and MP MH wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In the lower dentition, there is a greater contrast between the Middle Palaeolithic Modern Humans and the West Asian Neanderthals. In the Middle Palaeolithic Modern Humans, the first incisors both have a much higher median wear ratios and larger inter-quartile ranges. The lower canines similar median wear ratios, but the Middle Palaeolithic Modern Humans possess a larger inter-quartile range. In the West Asian Neanderthals the lower anterior teeth possess similar median wear ratios, while in the Middle Palaeolithic Modern Humans there are greater differences. The lower cheek teeth from both groups possess similar median wear ratios that approach those expected from the eruption sequence.

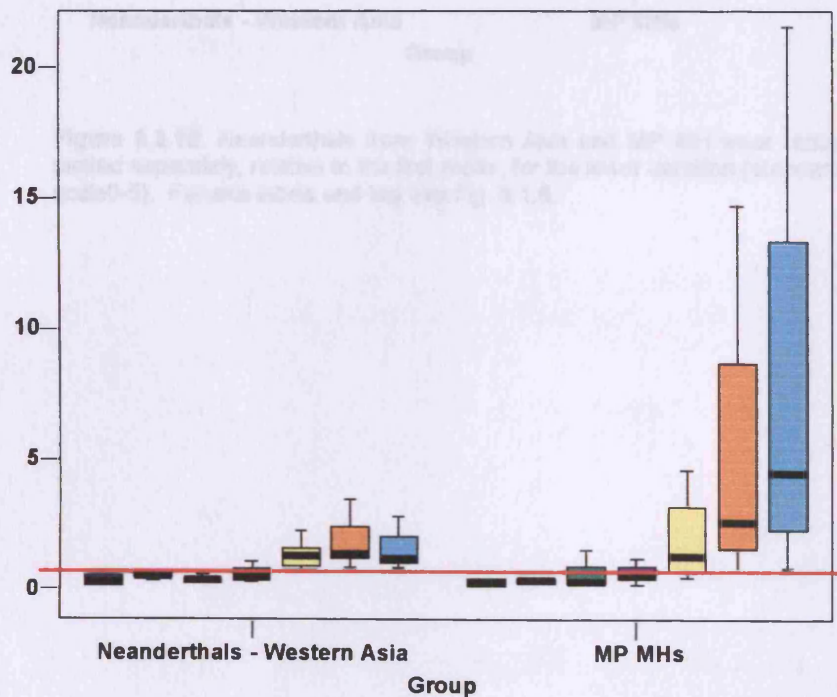


Figure 8.3.9: Neanderthals from Western Asia and MP MH wear ratios plotted separately, relative to the first molar, for the lower dentition (scale reduced to 0-20 to include all boxplots). For axis labels and key see Fig. 8.1.6.

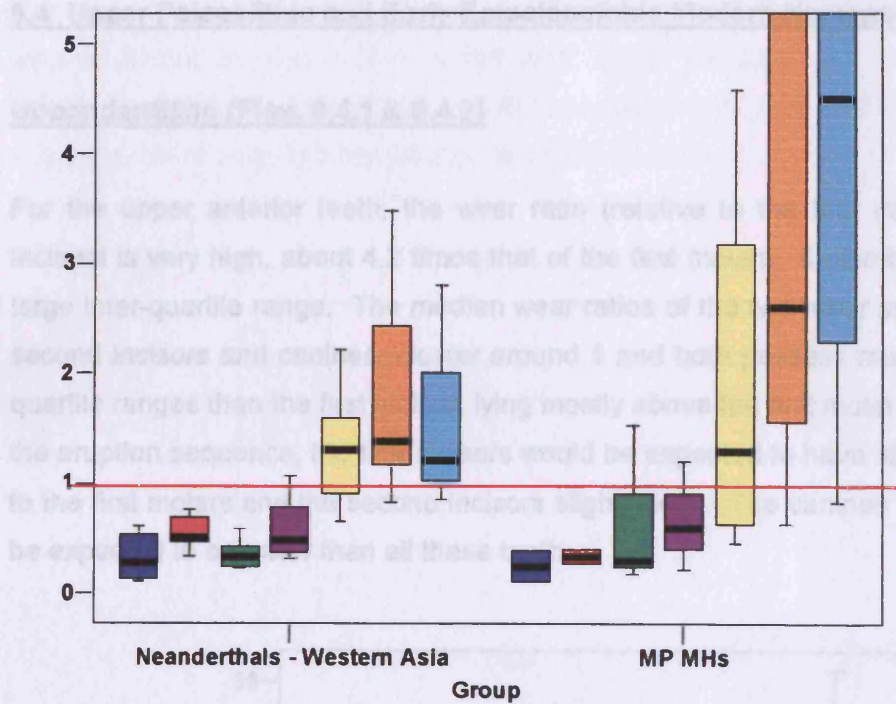


Figure 8.3.10: Neanderthals from Western Asia and MP MH wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

8.4 Upper Palaeolithic and Early Epipalaeolithic Modern Humans

Upper dentition (Figs. 8.4.1 & 8.4.2)

For the upper anterior teeth, the wear ratio (relative to the first molar) of the first incisors is very high, about 4.2 times that of the first molars. It also has an extremely large inter-quartile range. The median wear ratios of the two other anterior teeth, the second incisors and canines, cluster around 1 and both possess much smaller inter-quartile ranges than the first incisor, lying mostly above the first molar line. In terms of the eruption sequence, the first incisors would be expected to have similar wear ratios to the first molars and the second incisors slightly less. The canines wear ratio would be expected to be lower than all these teeth.

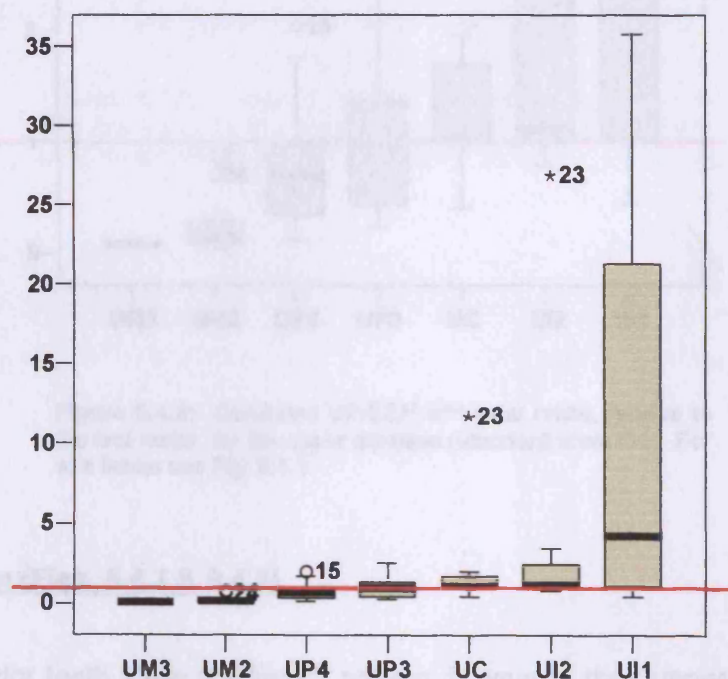


Figure 8.4.1: Combined UP/EEP MH wear ratios, relative to the first molar, for the upper dentition (scale reduced to 0-35 to include all outliers and boxplots). For axis labels see Fig. 8.1.1.

The upper third premolars are at the crossover point of the graph, between the anterior and cheek teeth. Their median wear ratio is about 1 and equal to that of the canines, while all of the other upper cheek teeth have median wear ratios of less than 1. The third premolar inter-quartile range overlaps with each of the anterior teeth as well as the fourth premolars. Together, the upper premolars have higher median wear ratios

and much larger inter-quartile ranges than the second and third molars, although these ranges do not overlap. This is not what would be expected from the eruption sequence, which would suggest that the premolars and second molar should show similar levels of wear and the third molar the least amount of wear.

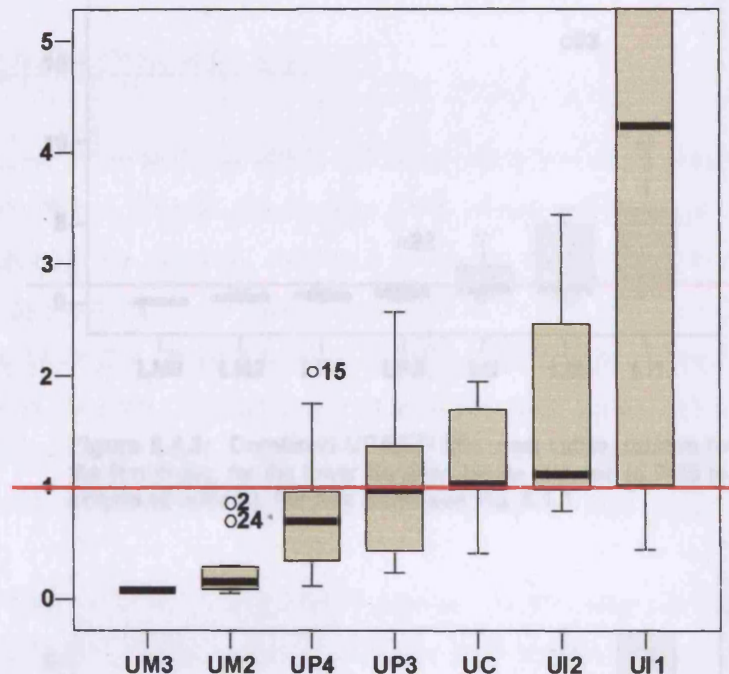


Figure 8.4.2: Combined UP/EEP MH wear ratios, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

Lower dentition (Figs. 8.4.3 & 8.4.4)

The lower anterior teeth show a different pattern of wear to their upper counterparts. The lower first incisors have a median wear ratio of about 1.8 and a large inter-quartile range. This is not what would be expected from the eruption sequence, which would suggest similar level of wear to the first molar. The lower second incisor and canine have wear ratios of about 0.8. Again, in terms of the eruption sequence, the second incisor would be expected to be slightly less worn than the first molar and first incisor with the canine showing much lower amounts of wear. Both these teeth possess large inter-quartile ranges, much larger than those of the lower cheek teeth and predominantly above the first molar line.

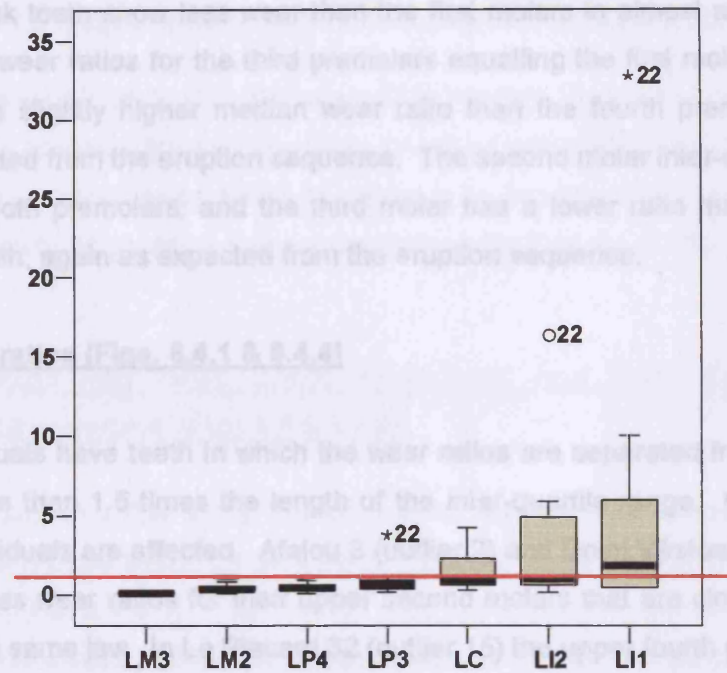


Figure 8.4.3: Combined UP/EEP MH wear ratios, relative to the first molar, for the lower dentition (scale reduced to 0-35 to include all outliers). For axis labels see Fig. 8.1.1.

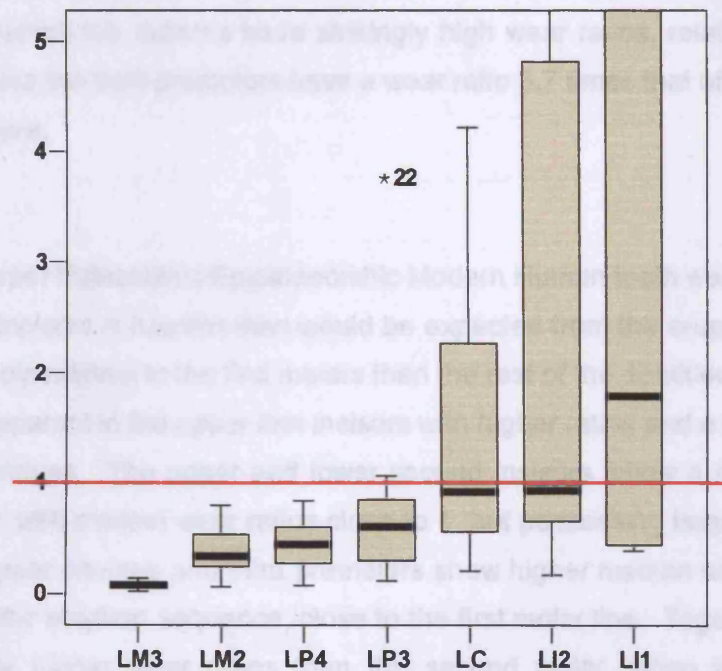


Figure 8.4.4: Combined UP/EEP MH wear ratios, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

The lower cheek teeth show less wear than the first molars in almost all individuals, with just a few wear ratios for the third premolars equalling the first molar. The third premolar has a slightly higher median wear ratio than the fourth premolars, which would be expected from the eruption sequence. The second molar inter-quartile range overlaps with both premolars, and the third molar has a lower ratio than any of the other cheek teeth, again as expected from the eruption sequence.

Outlying wear ratios (Figs. 8.4.1 & 8.4.4)

Several individuals have teeth in which the wear ratios are separated from the upper quartile by more than 1.5 times the length of the inter-quartile range. For the upper teeth, five individuals are affected. Afalou 3 (outlier 2) and Dolní Věstonice 16 (outlier 24) both possess wear ratios for their upper second molars that are close to the first molars from the same jaw. In Le Placard 32 (outlier 15) the upper fourth premolars are affected, with a wear ratio of about twice that of the first molars from the same jaw, while Dolní Věstonice 15 (outlier 23) possesses high wear ratios in its upper canines and second incisors, being over 10 and 25 times that of the first molar respectively.

For the lower teeth only one individual is affected in this way - Dolní Věstonice 14 (outlier 22), in which the incisors have strikingly high wear ratios, relative to the first molar. In addition the third premolars have a wear ratio 3.7 times that of the first molar from the same jaw.

Summary

In summary, Upper Palaeolithic/Epipalaeolithic Modern Human tooth wear in the upper and lower first incisors is heavier than would be expected from the eruption sequence and more variable relative to the first molars than the rest of the dentition. This pattern is even more apparent in the upper first incisors with higher ratios and a greater overall range in ratio values. The upper and lower second incisors follow a more expected pattern of wear, with median wear ratios close to 1, but possessing large inter-quartile ranges. The upper canines and third premolars show higher median wear ratios than expected from the eruption sequence, close to the first molar line. Together the upper premolars show higher wear ratios than the second molar, when they would be expected to be similar. Tooth wear in the lower cheek teeth and upper molars follows a more expected pattern.

Male and female Upper Palaeolithic and Early Epipalaeolithic Modern Humans

The Upper Palaeolithic and Early Epipalaeolithic Modern Humans were divided into male and female groups, based on the sexes identified in the literature (Chapter 7), but with the majority of specimens being of unknown or indeterminable sex, the group sizes were too small to produce any substantial results that are worthy of discussion here.

European, African and Asian Upper Palaeolithic and Early Epipalaeolithic Modern Humans compared (Figs 8.4.5-8.4.8)

The Upper Palaeolithic and Early Epipalaeolithic Modern Human specimens were divided into four groups based on their African, Asian, Central European or Western European origin (Table 8.4.1). This division was made to show whether any regional variations in the availability of resources had an effect on tooth wear patterns. Some of these regions contained low numbers specimens, limiting the conclusions that can be drawn from this comparison.

Site	Location	Number of specimens
Abri Pataud	W. Europe	1
Farincourt	W. Europe	1
Isturitz	W. Europe	2
Lachaud	W. Europe	2
La Madelaine	W. Europe	1
Le Placard	W. Europe	5
Dolni Vestonice	C. Europe	4
Pavlov	C. Europe	3
Nahal Ein Gev	W. Asia	1
Ohalo II	W. Asia	2
Afalou	N. Africa	5
Total		27

Table 8.4.1: Upper Palaeolithic and Early Epipalaeolithic specimens included in the current study, divided by geographical region.

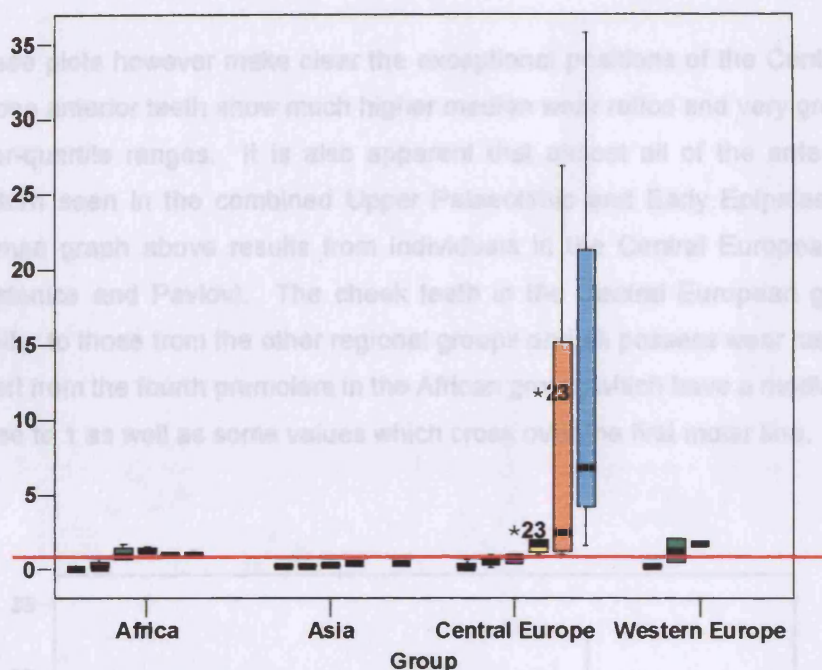


Figure 8.4.5: UP/EEP MH wear ratios plotted separately by region, relative to the first molar, for the upper dentition (scale reduced to 0-35 to include all boxplots). For axis labels and key see Fig. 8.1.6.

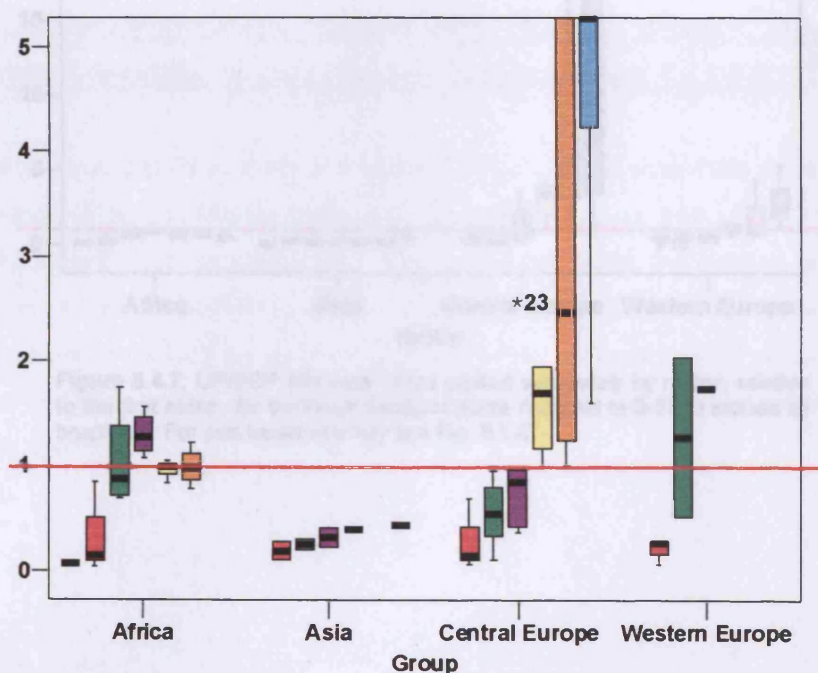


Figure 8.4.6: UP/EEP MH wear ratios plotted separately by region, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

These plots however make clear the exceptional positions of the Central Europeans, whose anterior teeth show much higher median wear ratios and very greatly increased inter-quartile ranges. It is also apparent that almost all of the anterior tooth wear pattern seen in the combined Upper Palaeolithic and Early Epipalaeolithic Modern Human graph above results from individuals in the Central European group (Dolní Věstonice and Pavlov). The cheek teeth in the Central European group are more similar to those from the other regional groups and all possess wear ratios less than 1, apart from the fourth premolars in the African group, which have a median wear ratio of close to 1 as well as some values which cross over the first molar line.

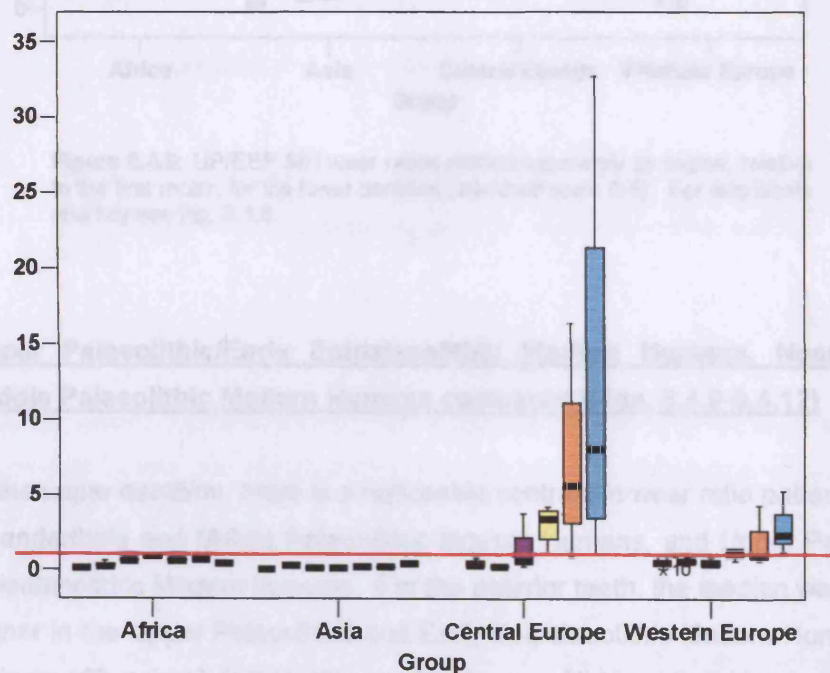


Figure 8.4.7: UP/EEP MH wear ratios plotted separately by region, relative to the first molar, for the lower dentition (scale reduced to 0-35 to include all boxplots). For axis labels and key see Fig. 8.1.6.

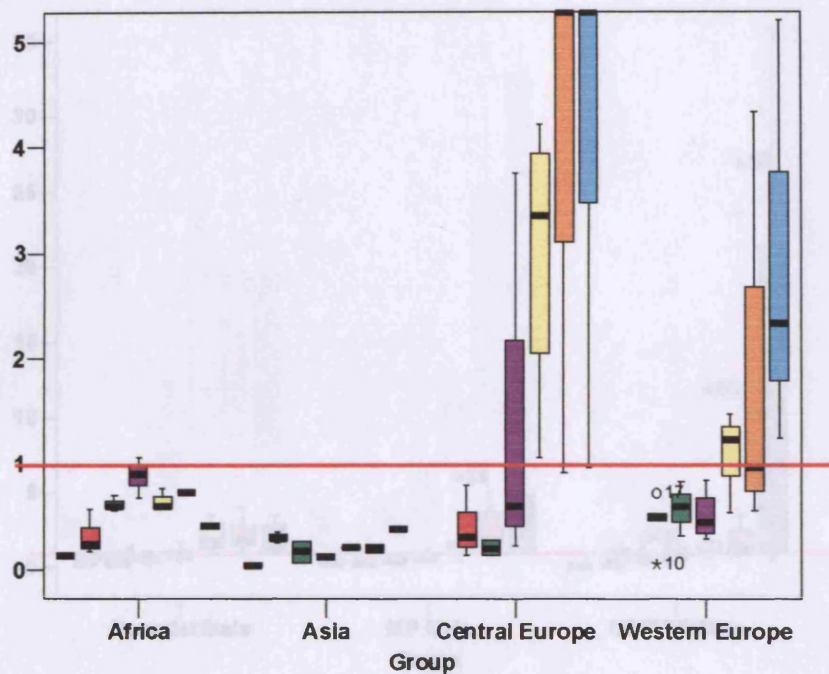


Figure 8.4.8: UP/EEP MH wear ratios plotted separately by region, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

Upper Palaeolithic/Early Epipalaeolithic Modern Humans, Neanderthals and Middle Palaeolithic Modern Humans compared (Figs. 8.4.9-8.4.12)

In the upper dentition, there is a noticeable contrast in wear ratio patterns between the Neanderthals and Middle Palaeolithic Modern Humans, and Upper Palaeolithic/Early Epipalaeolithic Modern Humans. For the anterior teeth, the median wear ratio is much higher in the Upper Palaeolithic and Early Epipalaeolithic Modern Humans upper first incisors with a much larger inter-quartile range. All Neanderthal anterior teeth show a clear separation from the cheek teeth, both in median and inter-quartile ranges of wear ratio values.

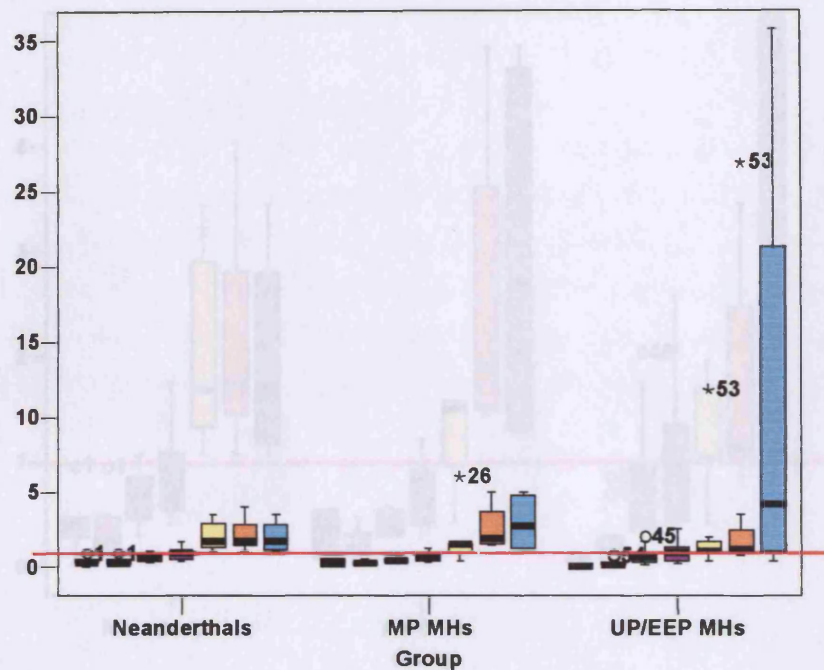


Figure 8.4.9: Neanderthal, MP MH and UP/EEP MH wear ratios plotted separately, relative to the first molar, for the upper dentition (scale reduced to 0-35 to include all outliers and box plots). For axis labels and key see Fig. 8.1.6.

in the lower dentition, there is contrast in the wear ratios of the anterior teeth between the Neanderthals, Middle Palaeolithic Modern Humans and Upper Palaeolithic/Early Epipalaeolithic Modern Humans. With the Upper Palaeolithic/Early Epipalaeolithic Modern Humans, it is particularly the upper first incisor that is distinctive, with the second incisor and canine medians and inter-quartile ranges only slightly greater than 1. In contrast, the median wear ratio of the second incisors and canines are higher in the Neanderthals and Middle Palaeolithic Modern Humans. The cheek teeth show more similar patterns of wear in both groups. The premolars show higher wear ratios in both the Neanderthals and Upper Palaeolithic/Epipalaeolithic Modern Human groups, with a median wear ratio of about 1 for their third premolars. The third molars have somewhat higher wear ratio in both the Neanderthal and Middle Palaeolithic Modern Humans groups.

relates to the wear ratios of the anterior teeth between the Neanderthals, Middle Palaeolithic Modern Humans and Upper Palaeolithic/Early Epipalaeolithic Modern Humans. The cheek teeth show more similar patterns of wear in both groups. The premolars show higher wear ratios in both the Neanderthals and Upper Palaeolithic/Epipalaeolithic Modern Human groups, with a median wear ratio of about 1 for their third premolars. The third molars have somewhat higher wear ratio in both the Neanderthal and Middle Palaeolithic Modern Humans groups.

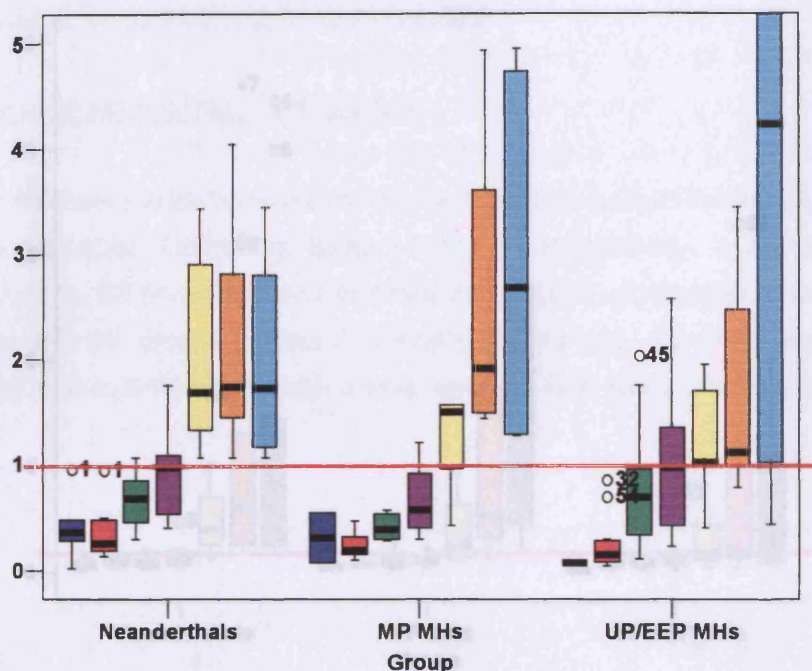


Figure 8.4.10: Neanderthal, MP MH and UP/EEP MH wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In the lower dentition, there is contrast in the wear ratios of the anterior teeth between the Neanderthals, Middle Palaeolithic Modern Humans and Upper Palaeolithic/Early Epipalaeolithic Modern Humans. In the Neanderthal and Middle Palaeolithic groups, the anterior teeth have higher median wear ratios, although the Neanderthals and Upper Palaeolithic/Early Epipalaeolithic Modern Humans have similar inter-quartile ranges. The Neanderthal and Middle Palaeolithic lower incisors have median wear ratios of between 2 and 3 times those of the Upper Palaeolithic and Early Epipalaeolithic Modern Humans. In the latter, the median wear ratios for the canines and second incisors are just below 1, although the inter-quartile range values are still large. The first incisor median wear ratio is somewhat higher than the other anterior teeth and also has a larger inter-quartile range, although this extends below 1. The cheek teeth more closely resemble the expected wear pattern from the eruption sequence in all groups, with most wear ratios falling below the first molar line.

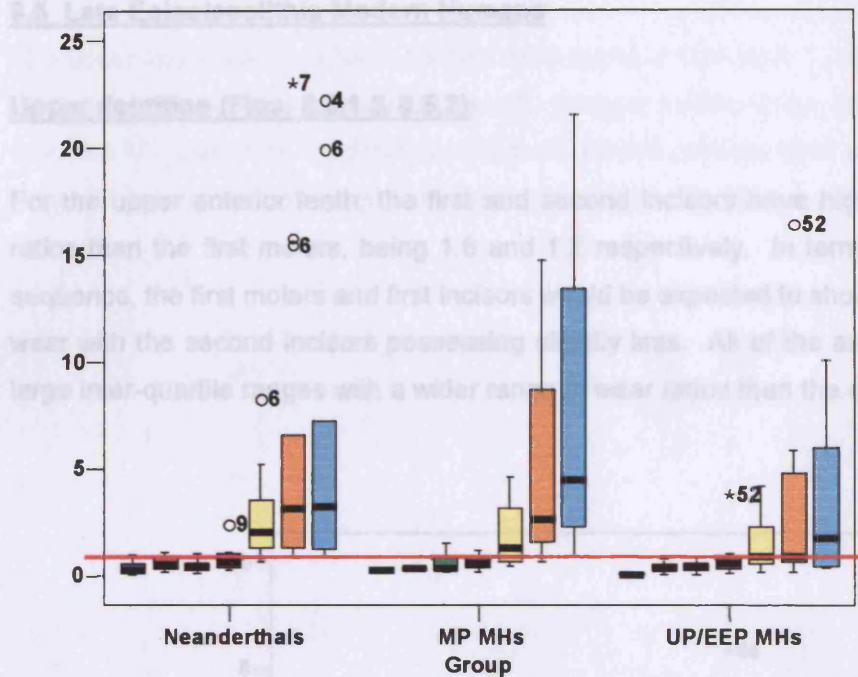


Figure 8.4.11: Neanderthal, MP MH and UP/EEP MH wear ratios plotted separately, relative to the first molar, for the lower dentition (scale reduced to 0-25 to include all box plots). For axis labels and key see Fig. 8.1.6.

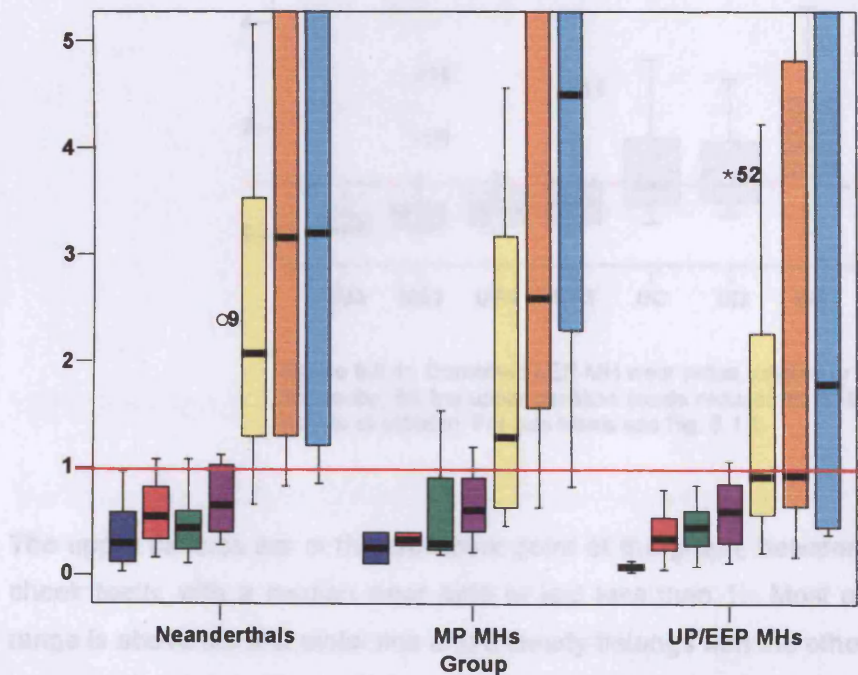


Figure 8.4.12: Neanderthal, MP MH and UP/EEP MH wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

8.5 Late Epipalaeolithic Modern Humans

Upper dentition (Figs. 8.5.1 & 8.5.2)

For the upper anterior teeth, the first and second incisors have higher median wear ratios than the first molars, being 1.6 and 1.2 respectively. In terms of the eruption sequence, the first molars and first incisors would be expected to show similar levels of wear with the second incisors possessing slightly less. All of the anterior teeth have large inter-quartile ranges with a wider range in wear ratios than the cheek teeth.

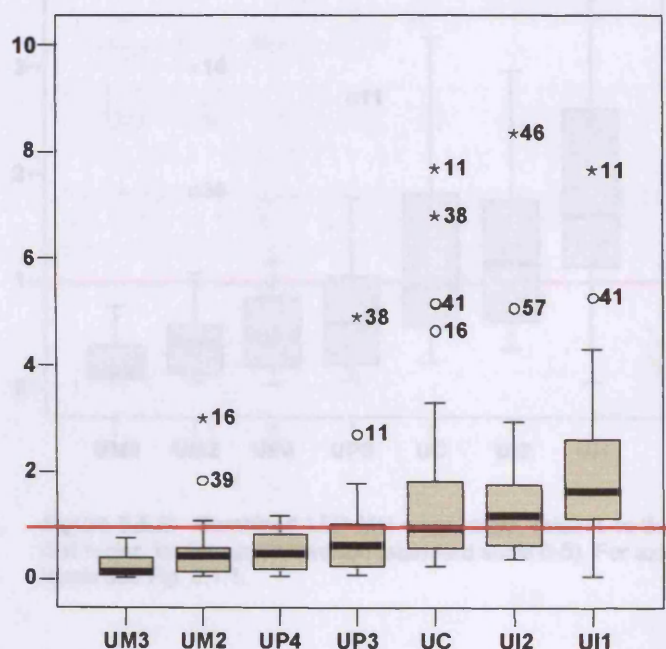


Figure 8.5.1: Combined LEP MH wear ratios, relative to the first molar, for the upper dentition (scale reduced to 0-10 to include all outliers). For axis labels see Fig. 8.1.1.

The upper canines are at the crossover point of the graph, between the anterior and cheek teeth, with a median wear ratio of just less than 1. Most of its inter-quartile range is above the first molar line and it clearly belongs with the other anterior teeth in terms of its wear state. This is not what would be expected from the eruption sequence, which would suggest that the canines should show similar wear ratios to the premolars and second molars.

The upper cheek teeth all have median wear ratios of less than 1, apart from the third premolar ratio which is slightly higher with a larger inter-quartile range just crossing over the M1 line. The third molars have the lowest median wear ratio and smallest range in wear values, as expected from the eruption sequence.

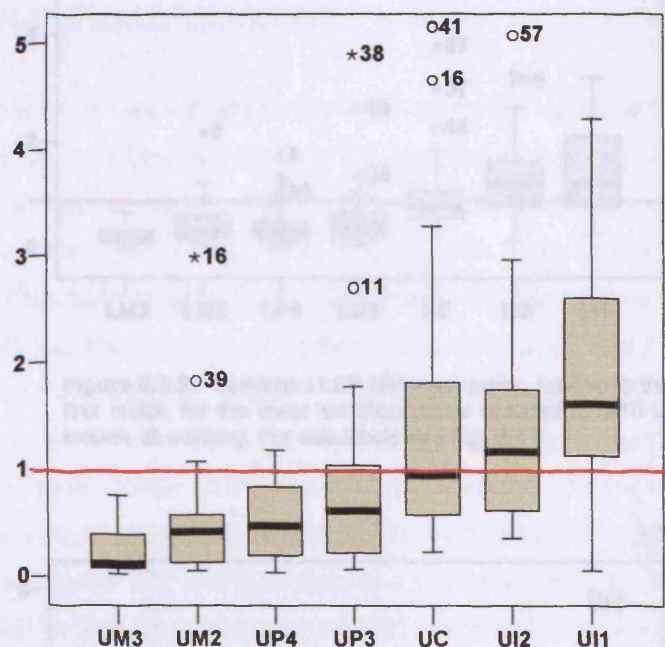


Figure 8.5.2: Combined LEP MH wear ratios, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

Lower dentition (Figs. 8.5.3 & 8.5.4)

The lower teeth have lower median wear ratios (relative to the first molar), and smaller inter-quartile ranges, than the upper teeth. The median wear ratios of both incisors cluster around 1.2, with inter-quartile ranges which overlap extensively. The lower canines are just below the crossover point of the graph, between the anterior and the cheek teeth, with a median wear ratio of about 0.9, and an inter-quartile range which overlaps with both the incisors and the third premolars. The lower anterior teeth possess wider variations in wear values than the cheek teeth.

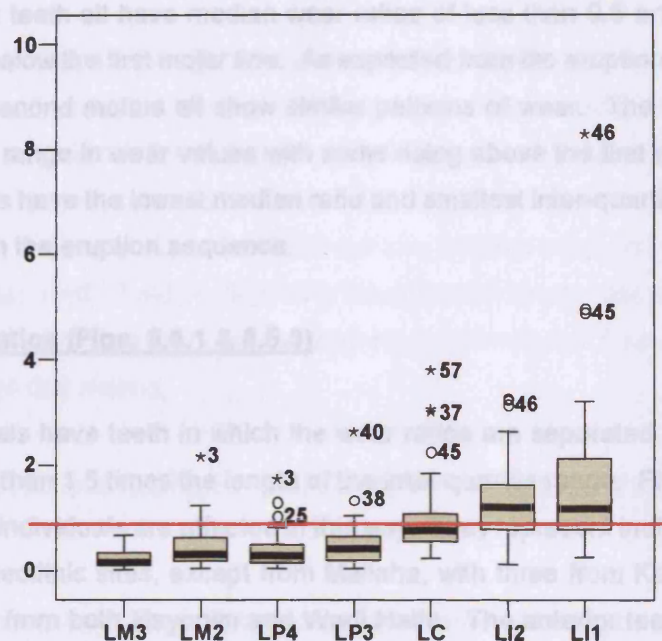


Figure 8.5.3: Combined LEP MH wear ratios, relative to the first molar, for the lower dentition (scale reduced to 0-10 to include all outliers). For axis labels see Fig. 8.1.1.

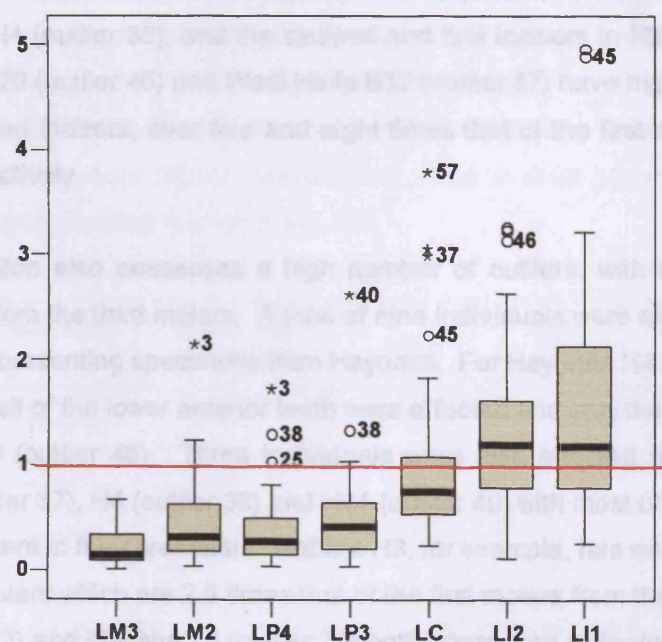


Figure 8.5.4: Combined LEP MH wear ratios, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

The lower cheek teeth all have median wear ratios of less than 0.5 and inter-quartile ranges that fall below the first molar line. As expected from the eruption sequence, the premolars and second molars all show similar patterns of wear. The second molars have the largest range in wear values with some rising above the first molar line. The lower third molars have the lowest median ratio and smallest inter-quartile range, again as expected from the eruption sequence.

Outlying wear ratios (Figs. 8.5.1 & 8.5.3)

Several individuals have teeth in which the wear ratios are separated from the upper quartile by more than 1.5 times the length of the inter-quartile range. Five of the upper teeth and seven individuals are affected in this way. They represent individuals from all the Late Epipalaeolithic sites, except from Mallaha, with three from Kebara, two from el-Wad and one from both Hayonim and Wadi Halfa. The anterior teeth possess the highest number of outliers. El-Wad 27 (outlier 11) has three affected teeth, the upper third premolars, canines and first incisors. The canines and first incisors show wear ratios almost eight times that of the first molars from the same jaw. In el-Wad 287 (outlier 16), the second molars and canines were affected. Of the three specimens from Kebara, the second molars were affected in H8 (outlier 39), the third premolars and canines in H4 (outlier 38), and the canines and first incisors in N357 (outlier 41). Both Hayonim H20 (outlier 46) and Wadi Halfa B32 (outlier 57) have high wear ratios in their upper second incisors, over four and eight times that of the first molars from the same jaw, respectively.

The lower dentition also possesses a high number of outliers, with all of the teeth affected, apart from the third molars. A total of nine individuals were affected with half of the outliers representing specimens from Hayonim. For Hayonim H4 (outlier 43) and H17 (outlier 45) all of the lower anterior teeth were affected and only the second incisor in Hayonim H19 (outlier 46). Three individuals were also affected from the site of Kebara, H3 (outlier 37), H4 (outlier 38) and H11 (outlier 40) with most of their high wear ratios being present in their premolars. Kebara H3, for example, has wear ratios for the lower third premolars which are 2.5 times that of the first molars from the same jaw. El-wad 233 (outlier 3) and Mallaha 70 (outlier 25) both possessed a single outlier for their lower fourth premolars. Kebara H3, Hayonim H19, Wadi Halfa B32 all possess high wear ratios in both their upper and lower teeth.

Summary

In summary, tooth wear in the upper anterior teeth is slightly heavier, relative to the upper first molar, than would be expected from the eruption sequence, and more variable than in the rest of the dentition. The lower incisors show a more expected wear pattern than their upper counterparts with lower medians and smaller ranges in wear ratios. The upper and lower canines are in a transitional position between the anterior and cheek teeth. Tooth wear in both the upper and lower cheek teeth is similar to the pattern expected from the eruption sequence, with most of these teeth showing less wear than the first molars.

Male and female Late Epipalaeolithic Modern Humans compared (Figs. 8.5.5-8.5.7)

Studies of recent hunter-gatherers have reported differences in the use of teeth by males and females (Pedersen, 1947). The results for the Neanderthals and Inuit specimens included in this study (see above) have also shown differences in wear patterns between males and females. The Late Epipalaeolithic Modern Humans were therefore divided into male and female groups, based on the sexes identified in the literature (Chapter 7) (Table 8.5.1). Late Epipalaeolithic Modern Humans show similar tooth wear patterns in their upper dentitions, although there is a difference in their upper second incisors, with a median wear ratio of about 1.4 in the males, while the females have a median wear ratio of less than 1. The female Late Epipalaeolithic Modern Humans also show higher median wear ratios in their premolars, with their inter-quartile ranges crossing the first molar line.

Site	Location	Number of specimens	Male	Female	Sex Ind. or unknown
El Wad	Levant	17	-	-	17
Hayonim	Levant	9	7	2	-
Kebara	Levant	5	1	-	4
Mallaha	Levant	18	6	5	7
Wadi Halfa	Levant	9	3	6	-
Total		58	17	13	28

Table 8.5.1: Late Epipalaeolithic specimens included in the current study, divided by site and sex.

The male and female Late Epipalaeolithic Modern Humans also show similar patterns of wear in their lower dentitions. The male lower incisors have somewhat higher median wear ratios and much larger inter-quartile ranges, with some individuals having wear ratios in their first incisors over eight times that of the first molars from the same jaw. The canines and premolars show similar wear patterns in the two sexes, but the second and third molars have higher median wear ratios in the female group with slightly larger inter-quartile ranges.

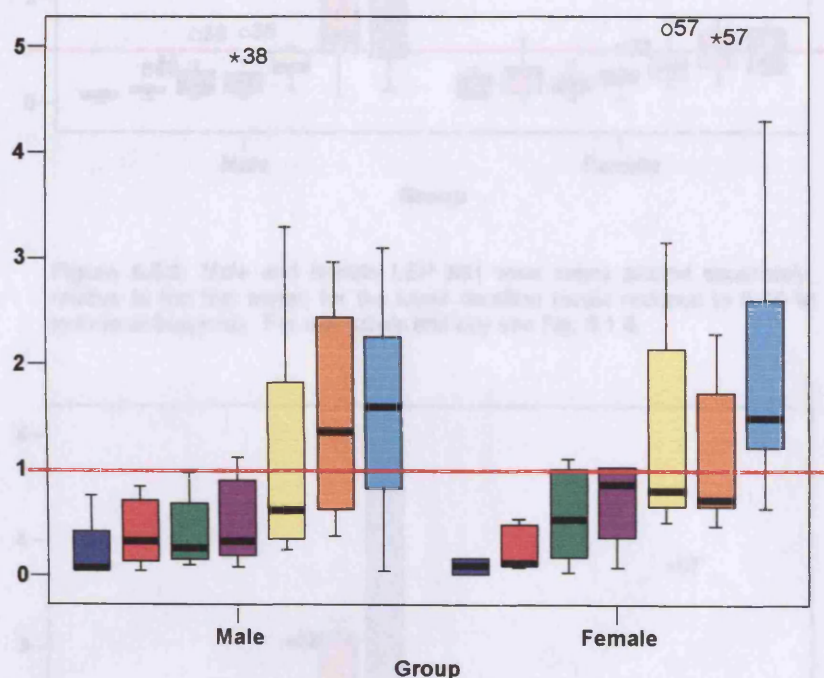


Figure 8.5.5: Male and female LEP MH wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

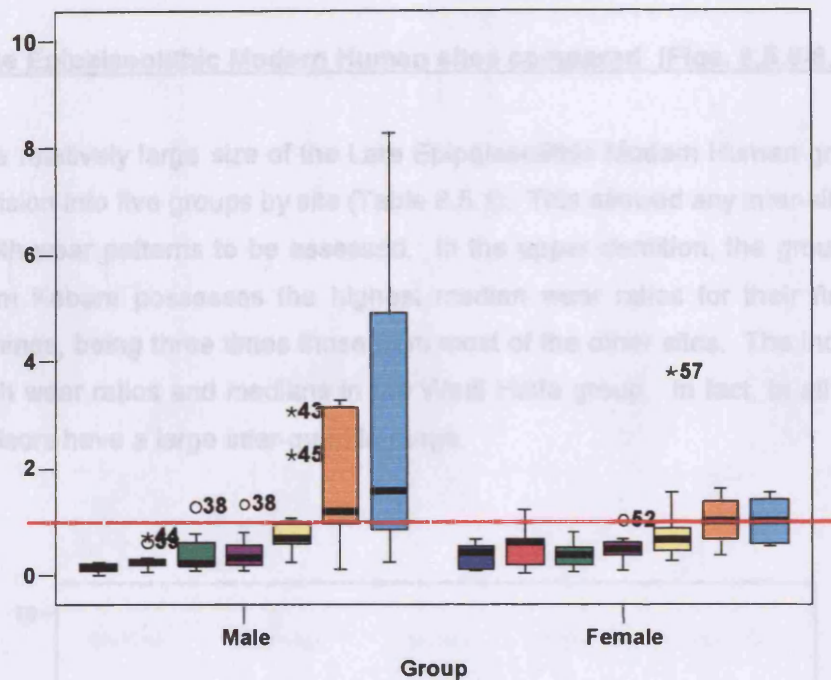


Figure 8.5.6: Male and female LEP MH wear ratios plotted separately, relative to the first molar, for the lower dentition (scale reduced to 0-10 to include all boxplots). For axis labels and key see Fig. 8.1.6.

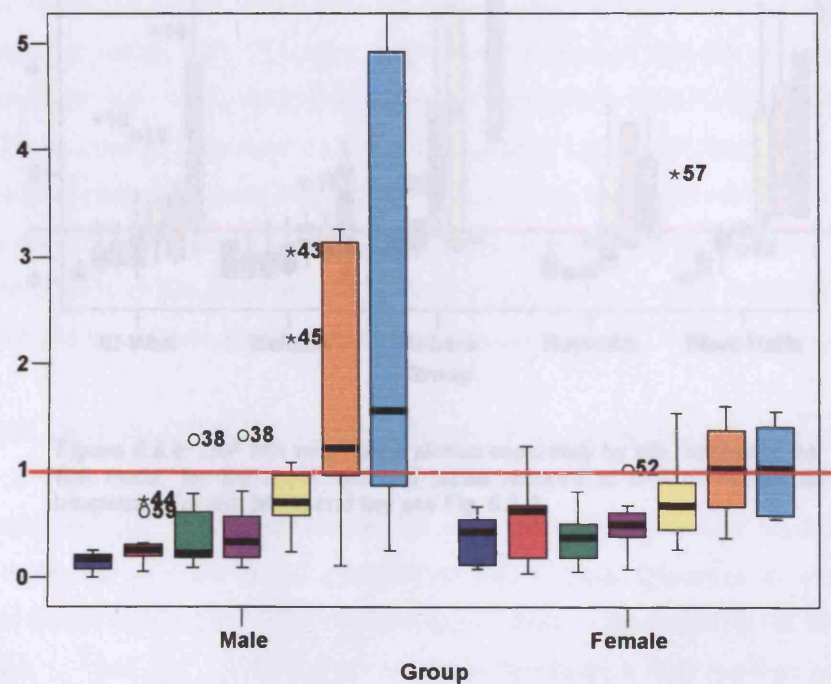


Figure 8.5.7: Male and female LEP MH wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

Late Epipalaeolithic Modern Human sites compared (Figs. 8.5.8-8.5.11)

The relatively large size of the Late Epipalaeolithic Modern Human group enabled its division into five groups by site (Table 8.5.1). This allowed any inter-site differences in tooth wear patterns to be assessed. In the upper dentition, the group of specimens from Kebara possesses the highest median wear ratios for their first incisors and canines, being three times those from most of the other sites. The incisors also have high wear ratios and medians in the Wadi Halfa group. In fact, in all groups the first incisors have a large inter-quartile range.

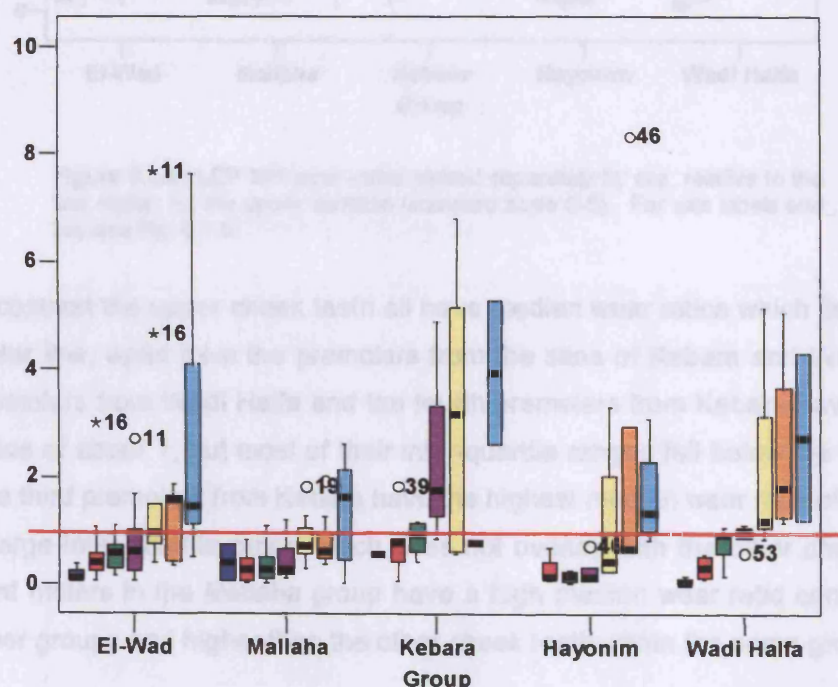


Figure 8.5.8: LEP MH wear ratios plotted separately by site, relative to the first molar, for the upper dentition (scale reduced to 0-10 to include all boxplots). For axis labels and key see Fig. 8.1.6.

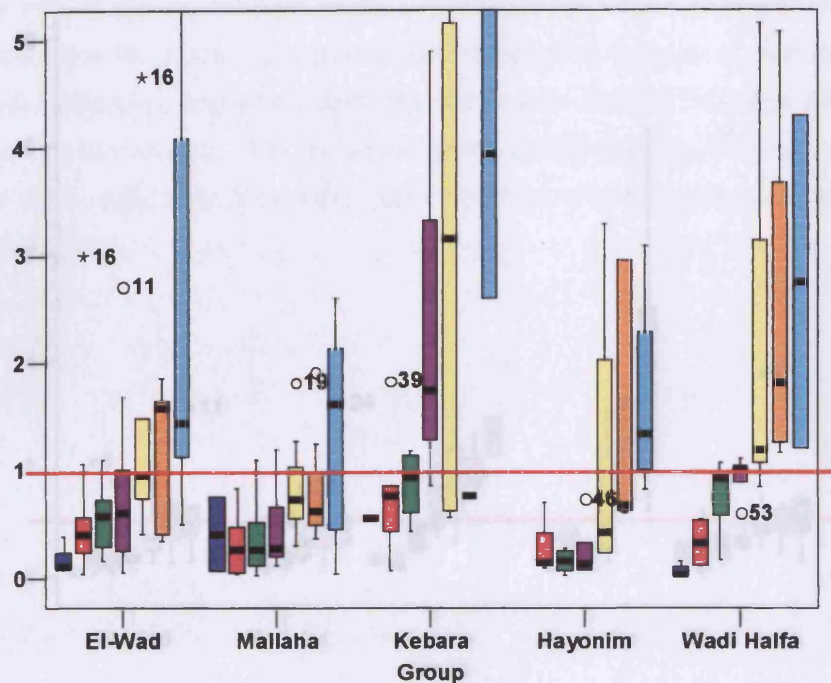


Figure 8.5.9: LEP MH wear ratios plotted separately by site, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In contrast the upper cheek teeth all have median wear ratios which lie below the first molar line, apart from the premolars from the sites of Kebara and Wadi Halfa. The premolars from Wadi Halfa and the fourth premolars from Kebara have median wear ratios of about 1, but most of their inter-quartile ranges fall below the first molar line. The third premolars from Kebara have the highest median wear ratio of about 1.7, with a large inter-quartile range which does not overlap with the other cheek teeth. The third molars in the Mallaha group have a high median wear ratio compared with the other groups and higher than the other cheek teeth within the same group.

In the lower dentition, the pattern of wear ratios varies between sites. The dentitions from Hayonim possess very high wear ratios for their incisors, as well as large inter-quartile ranges. The first incisors, for example, have a median wear ratio almost five times that of el-Wad, Mallaha and Wadi Halfa. Late Epipalaeolithic Modern Humans from Kebara also have high median wear ratios in their lower anterior teeth, between about 1.7 and 2.4. Their third premolars also have a high median wear ratio, above the first molar line, and a large inter-quartile range. In contrast, none of the third premolars from the other groups have wear ratios which rise above the first molar line.

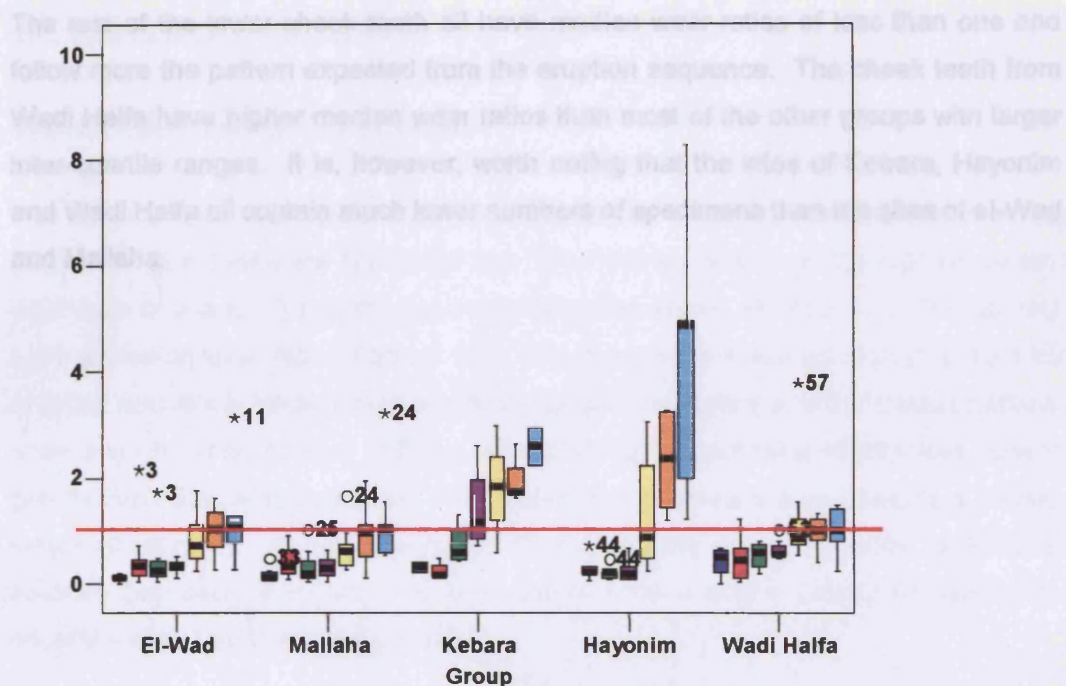


Figure 8.5.10: LEP MH wear ratios plotted separately by site, relative to the first molar, for the lower dentition (scale reduced to 0-10 to include all boxplots). For axis labels and key see Fig. 8.1.6.

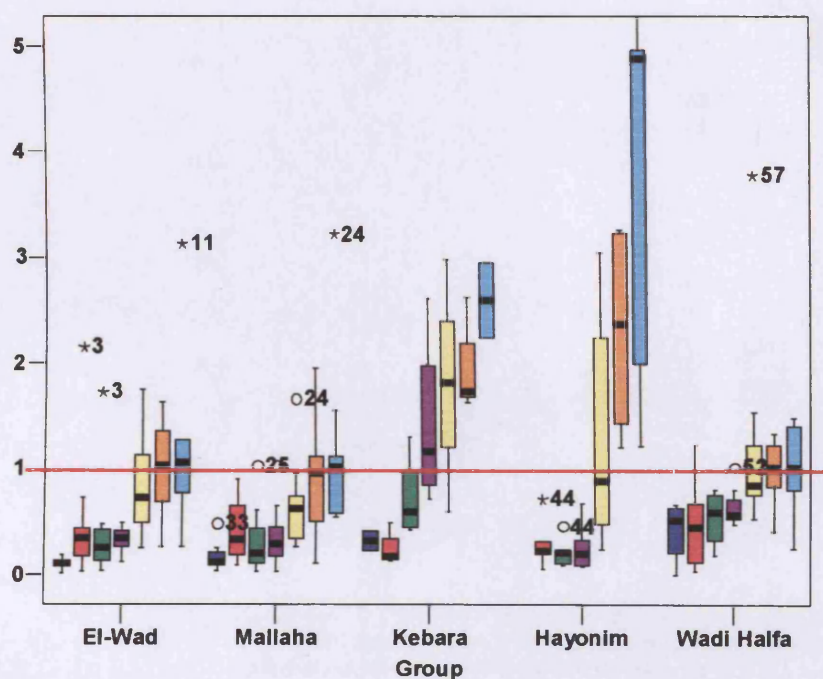


Figure 8.5.11: LEP MH wear ratios plotted separately by site, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

The rest of the lower cheek teeth all have median wear ratios of less than one and follow more the pattern expected from the eruption sequence. The cheek teeth from Wadi Halfa have higher median wear ratios than most of the other groups with larger inter-quartile ranges. It is, however, worth noting that the sites of Kebara, Hayonim and Wadi Halfa all contain much lower numbers of specimens than the sites of el-Wad and Mallaha.

8.6 Mesolithic Modern Humans

Upper dentition (Figs 8.6.1 & 8.6.2)

The upper anterior teeth show a range in wear ratios (relative to the first molar) falling both above and below the first molar line. The first incisors have the highest median wear ratio of about 1.6 and the second incisors the lowest at about 1.1. The canines have a median wear ratio of about 1.3. This is not what would be expected from the eruption sequence, which would suggest that the first molars and first incisors should show a similar level of wear with the second incisors possessing slightly less, and all greater than that of the canines. The upper third premolars also possess a median wear ratio above 1. In fact, it is higher than that of the second incisors. In terms of eruption sequence, they would be expected to show a similar pattern of wear to the second molars and the fourth premolar.

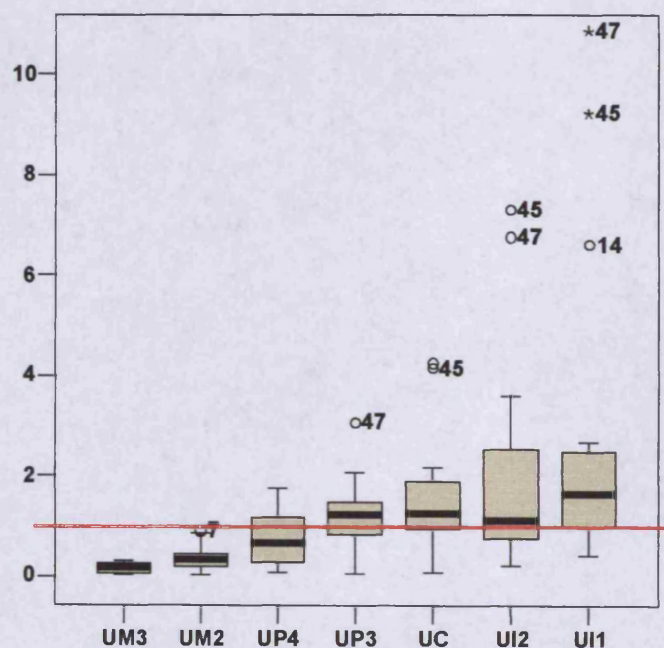


Figure 8.6.1: Combined Mesolithic MH wear ratios, relative to the first molar, for the upper dentition (scale reduced to 0-10 to include all outliers). For axis labels see Fig. 8.1.1.

The inter-quartile range of the fourth premolars overlaps extensively with both the anterior and cheek teeth. Its median wear ratio is below 1 and belongs with the second

and third molars in terms of its wear state. The second and third molars show the lowest median wear ratios with the smallest inter-quartile ranges. In fact, none of the wear ratios lie above the first molar line. The third molars have the lowest median wear ratio, as expected from the eruption sequence.

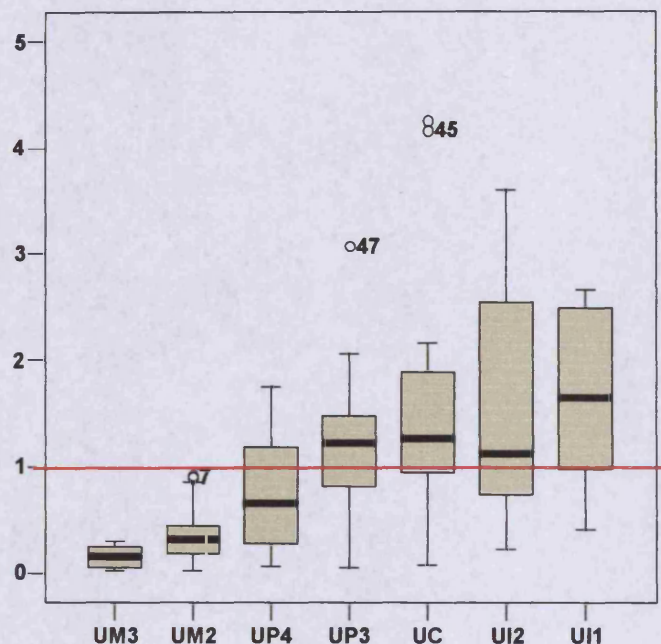


Figure 8.6.2: Combined Mesolithic MH wear ratios, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

Lower dentition (Figs. 8.6.3 & 8.6.4)

The lower dentition shows a noticeably different wear pattern to its upper counterpart. For the lower anterior teeth, the wear ratios are much lower than in the upper anterior teeth (relative to the first molar) with much smaller inter-quartile ranges. The first incisors have the highest median wear ratio, falling just below the first molar line. The second incisors have the largest inter-quartile range, but their median wear ratio is low at about 0.7. The pattern of wear shown by the second incisors is not what would be expected from the eruption sequence, which would suggest a similar level of wear for both the first incisors and first molars and slightly less in the second incisors. The median wear ratio of the lower canines also falls below the first molar line and is similar to that of the premolars and second molars, as expected from the eruption sequence.

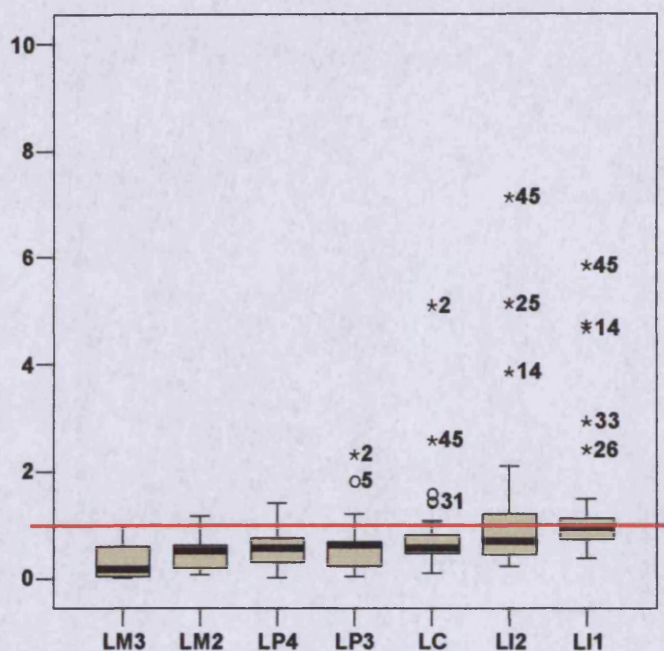


Figure 8.6.3: Combined Mesolithic MH wear ratios, relative to the first molar, for the lower dentition (scale reduced to 0-10 to include all outliers). For axis labels see Fig. 8.1.1.

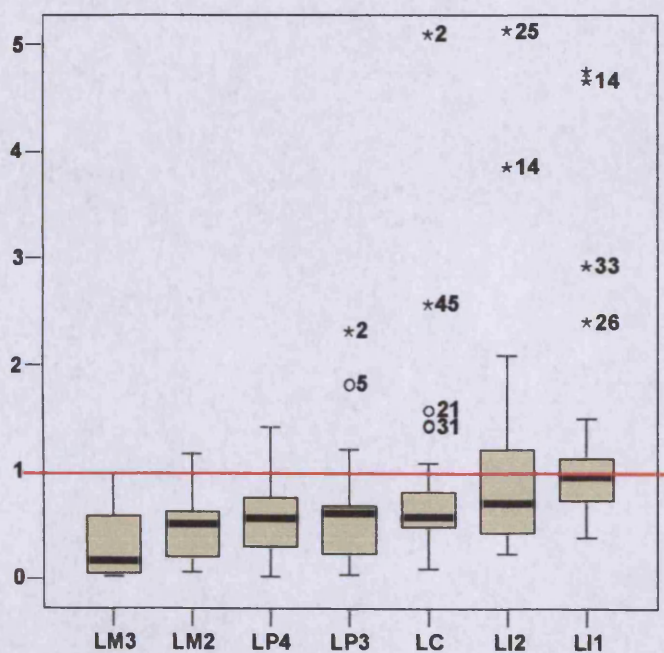


Figure 8.6.4: Combined Mesolithic MH wear ratios, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

The lower canines, premolars and second molars all show similar ranges in wear ratios with some values lying above the first molar line. The third molars have the lowest median wear ratio, as expected from the eruption sequence.

Outlying wear ratios (Figs. 8.6.1 & 8.6.3)

A few individuals have teeth in which the wear ratios are separated from the upper quartile by more than 1.5 times the length of the inter-quartile range. For the upper teeth there are nine outliers, seven for the anterior teeth and two for the cheek teeth. Seven of the outliers represent individuals from the site of Tévéc. In Tévéc 16 (outlier 47) and 10 (outlier 45) all of the upper anterior teeth were affected, as well as the third premolars in Tévéc 16. Their incisors show wear ratios between 6 and 10.5 times that of the first molars from the same jaw. Dragsholm B (outlier 14) and Arruda 3 (outlier 7) both possess single outliers for their first incisors and second molars respectively.

For the lower teeth, nine individuals are affected, including 14 outliers in total. These outliers are concentrated in the lower anterior teeth. Of the cheek teeth only the third premolars are affected with two outliers. Four specimens from Moita do Sebastião, 3 (outlier 33), 11 (outlier 21), 17 (outlier 25), 19 (outlier 26), 27 (outlier 31) possess outliers for their anterior teeth. Moita do Sebastião 17 has the highest outlier from this site with a wear ratio for its second incisors which is over five times that of the first molars from the same jaw. In Dragsholm B (outlier 14) both incisors are affected and two specimens from Arruda, 81.61.5.C (outlier 2) and 81.61.5.O (outlier 5), possess outliers for their canines and third premolars. All of the anterior teeth of Tévéc 10 (outlier 45) were affected, mirroring the outliers in its upper teeth, with wear ratios in its incisors between six and seven times that of the first molars from the same jaw.

Summary

In summary, tooth wear in upper anterior teeth is slightly heavier than would be expected from the eruption sequence, and more variable relative to the upper first molar than the rest of the dentition. The lower incisors showed a more expected pattern of wear with much smaller inter-quartile ranges than their upper counterparts. The upper third premolars possess a pattern of wear more similar to the anterior teeth than any of the cheek teeth. Tooth wear in the lower cheek teeth follows a more expected pattern of wear, with only a few value rising above the first molar line.

Male and female Mesolithic Modern Humans compared (Figs. 8.6.5 & 8.6.6)

The Mesolithic Modern Humans were divided into male and female groups, based on the sexes identified in the literature (Chapter 7) (Table 8.6.1). This division was made to assess whether differences in male and female tooth wear patterns were present within the Mesolithic Modern Humans group, as found in other groups included in this study. Males and females show slightly different patterns of wear in their upper dentitions. Females show higher median wear ratio in their upper incisors, and second incisors with a median wear ratio of over 2.5 times that of the males. The canines and cheek teeth show similar patterns of wear with the third premolars from both groups possessing median wear ratios above the first molar line.

Site	Location	Number of specimens	Male	Female	Sex ind. or unknown
Dragsholm	Scandinavia	2	1	1	-
Korsør Nor	Scandinavia	2	1	-	1
Melby	Scandinavia	1	1	-	-
Vedbæk	Scandinavia	2	1	1	-
Baume de Montclus	France	1	-	1	-
Gramat	France	2	1	1	-
Rochereil	France	1	1	-	-
Téviec	France	7	4	3	-
Cabeço da Arruda	Portugal	9	-	-	9
Moita do Sebastião	Portugal	19	4	6	9
Total		46	14	13	19

Table 8.6.1: Mesolithic specimens included in the current study, divided by geographic region and sex.

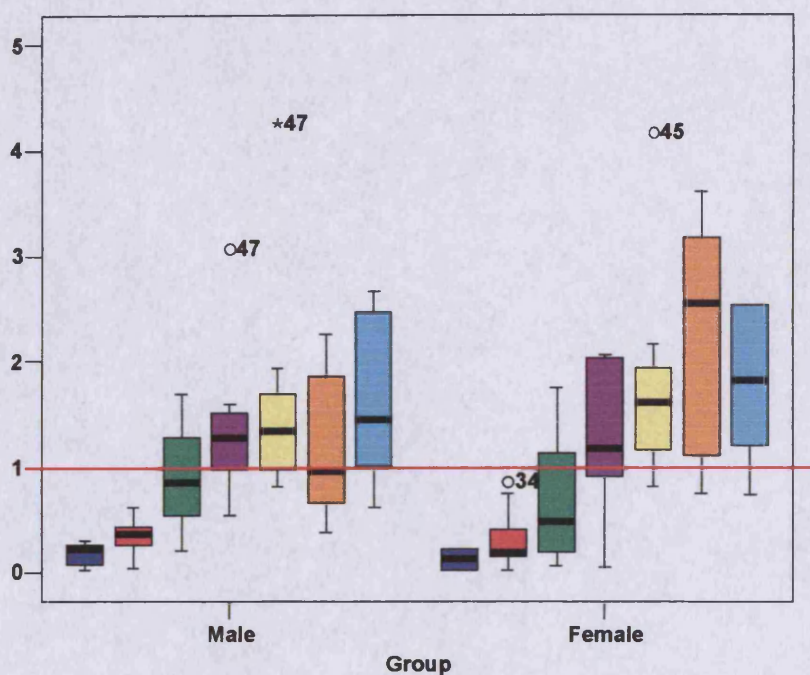


Figure 8.6.5: Male and female Mesolithic MH wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

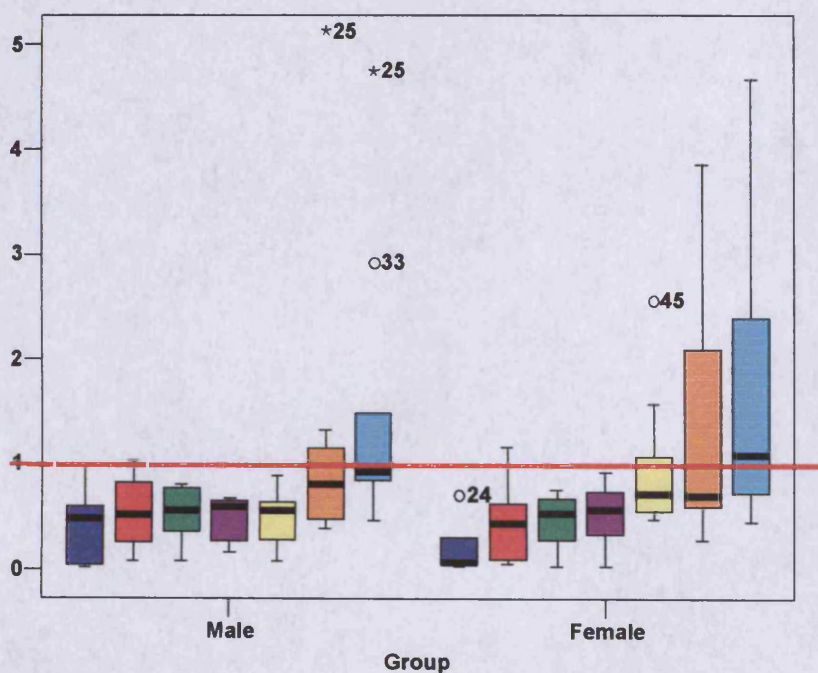


Figure 8.6.6: Male and female Mesolithic MH wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In their lower dentitions the male and female Mesolithic Modern Humans show very similar wear patterns. The only main difference is the size of the inter-quartile ranges for both incisors, which are much larger in the females. The third molars also have a higher median wear ratio and a larger inter-quartile range in the male group.

Mesolithic sites compared (Figs. 8.6.7-8.6.9)

The Mesolithic Modern Humans were also divided into two groups based on their location in either Scandinavia or France/Portugal to assess whether any regional variations in resource availability had an effect on their tooth wear patterns (Table 8.6.1). In the upper dentition, the pattern of wear ratios is similar for Scandinavian and French/Portuguese Mesolithic Modern Humans. The exception is the inter-quartile range of the first incisors, which is much larger in the Scandinavian group. The second incisors, canines and third premolars also show slightly higher median wear ratios in the French/Portuguese group and the median wear ratio for the second molar is higher in the Scandinavian group.

In the lower dentition, only a limited number of wear ratios were available for the Scandinavian group, but they show some notable differences to the French/Portuguese group. In the Scandinavian group, the first incisors have a lower median wear ratio, but a much larger inter-quartile range. The rest of the dentition shows similar wear patterns, apart from the second molars which have a higher median wear ratio in the Scandinavian group.

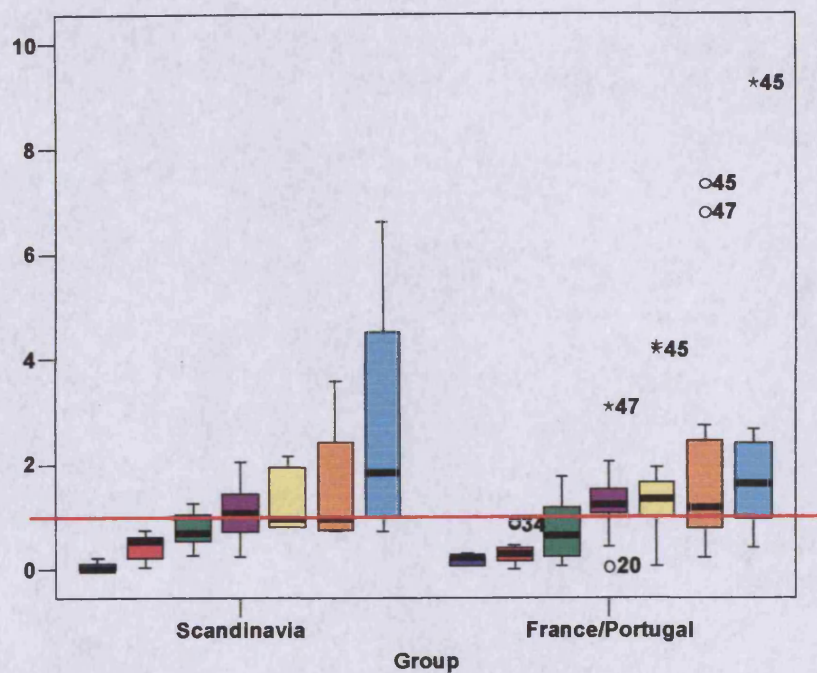


Figure 8.6.7: Mesolithic MH wear ratios plotted separately by region, relative to the first molar, for the upper dentition (scale reduced to 0-10 to include all boxplots). For axis labels and key see Fig. 8.1.6.

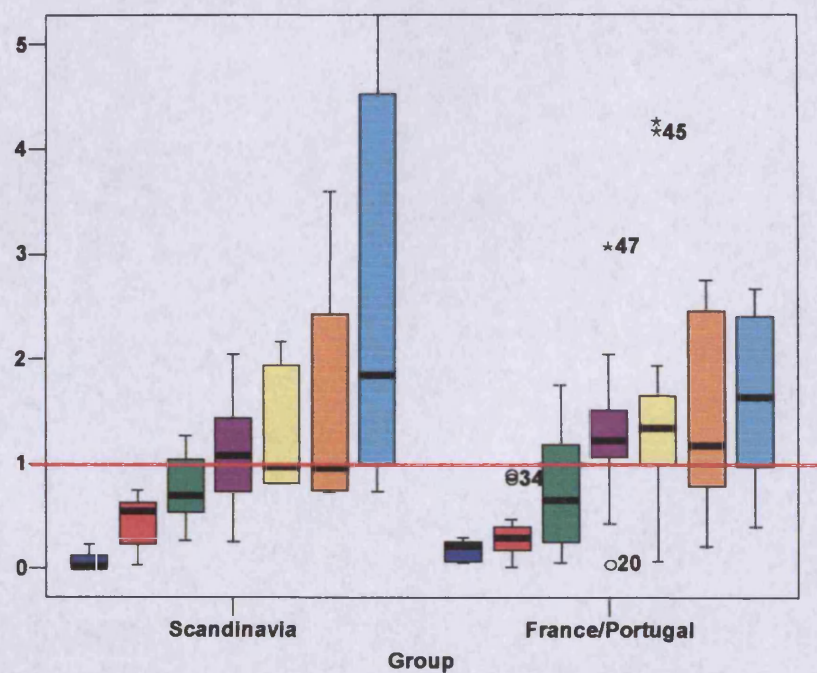


Figure 8.6.8: Mesolithic MH wear ratios plotted separately by region, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

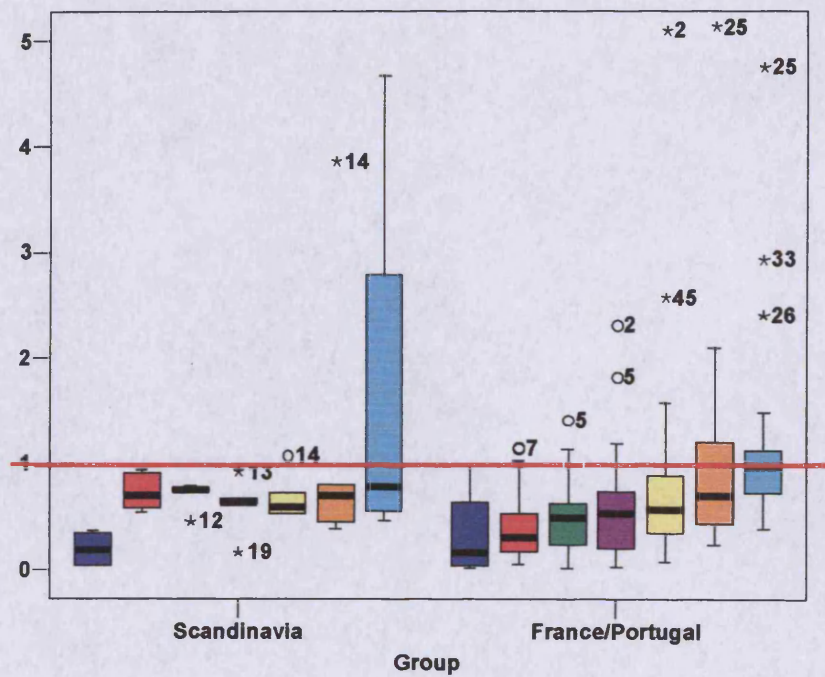


Figure 8.6.9: Mesolithic MH wear ratios plotted separately by region, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

8.7 Neolithic Modern Humans

Upper dentition (Fig. 8.7.1)

For the upper teeth, the median wear ratios (relative to the first molar) approach the pattern expected from the eruption sequence. The first incisors have a median wear ratio of just greater than 1 and the second incisor just below 1. The premolars and molars all have wear medians below 0.5. The upper canines are at the cross over point of the graph between the anterior and cheek teeth. While they possess a median wear ratio of less than 1, the inter-quartile range and overall range of wear ratios are more similar to the incisors.

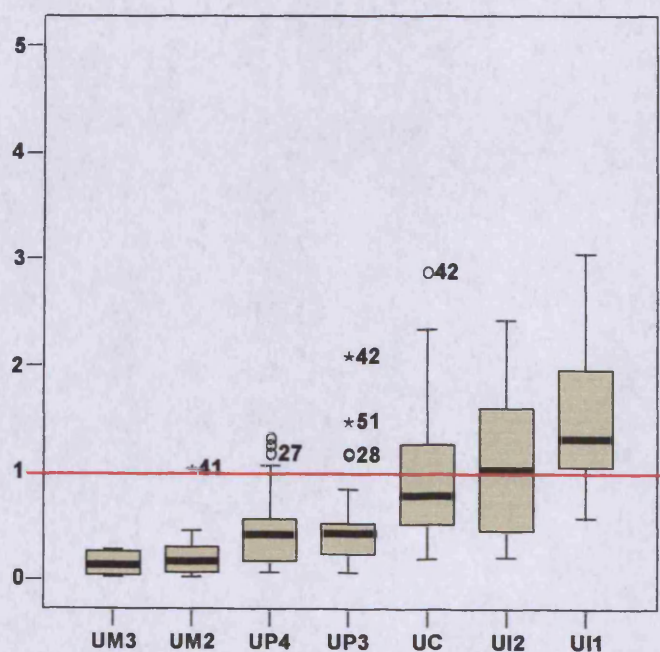


Figure 8.7.1: Combined Neolithic MH wear ratios, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

In terms of the eruption sequence, they would be expected to be more similar to the premolars and second molars. Together the upper premolars have slightly higher wear ratios and larger inter-quartile ranges than the second and third molars and would be expected to be more similar to the second molars.

Lower dentition (Fig. 8.7.2)

The lower teeth show a similar pattern of wear to their upper counterparts, approaching that expected from the eruption sequence, but most possess slightly lower median wear ratios, inter-quartile ranges and overall ranges in wear ratios.

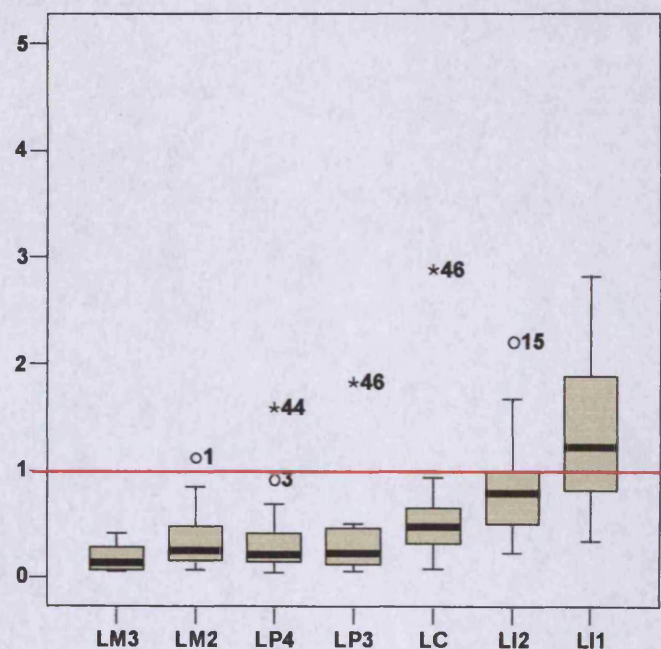


Figure 8.7.2: Combined Neolithic MH wear ratios, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels see Fig. 8.1.1.

The first incisors have a median wear ratio just above 1, the largest inter-quartile range being over twice that of any other tooth, and the largest overall range in wear ratios. The second incisors have a median wear ratio of about 0.8. The canines have a smaller inter-quartile range than the two incisors and a lower median wear ratio. They hold a transitional position between the anterior teeth and cheek teeth. In terms of the eruption sequence, they would be expected to be most similar to the premolars and

second molars. The third molars possess the lowest median wear ratio and smallest inter-quartile range, as expected from their position within the eruption sequence.

Outlying wear ratios (Figs. 8.7.1 & 8.7.2)

Several of the Neolithic Modern Humans have teeth in which the wear ratios are separated from the upper quartile by more than 1.5 times the inter-quartile range. The upper teeth possess nine outliers affecting seven individuals. Only teeth from phase 2 in the eruption sequence were affected: the canines, premolars and second molars. The premolars possess seven out of the nine outliers. Of the seven specimens affected, three come from the site of Borreby (outliers 25, 27 and 28), two from Kyndelose (35 and 42) and one from Uggerslevgaard (51). In most of these specimens only a single tooth was affected, apart from in Borreby III (outlier 25) where both premolars have outliers, and in Kyndelose XXII (outlier 42) where the third premolars and canines have outliers.

In the lower dentition there are six outliers affecting five specimens. Two of the specimens come from the site of Hatoula (outlier 1 and 3), one from Atlit Yam (outlier 15), one from Kyndelose (outlier 44) and one from Raevehoj (outlier 46). The lower second incisors, canines, third premolars and second molars all possess a single outlier, while the fourth premolars have two. Raevehoj II is the only individual with more than one tooth affected, possessing outlier for the third premolars and the canines. None of the Neolithic Modern Humans possess outliers for both their upper and lower teeth. All of the outliers are also relatively low when compared to other hominin groups from this study.

Summary

The pattern of wear in the upper and lower dentitions of the Neolithic Modern Humans is to some extent similar to what would be expected from the eruption sequence. The incisors and canines tend to be a bit more heavily worn than expected. The upper and lower canines possess an intermediate pattern of wear between that of the anterior teeth and cheek teeth. The lower second incisors also show a different pattern of wear to that expected from the eruption sequence, with a lower median wear ratio than the first incisors and first molars.

Male and female Neolithic Modern Humans compared (Figs. 8.7.3 & 8.7.4)

The Neolithic Modern Humans were divided into male and female groups, based on the sexes identified in the literature (Chapter 7) (Table 8.7.1). This division was made to assess whether the differences in male and female tooth wear patterns, shown by other hominin groups included in this study, were also present in the Neolithic group. In the upper dentition the males and females show similar patterns of wear in most of their teeth, although the males show higher median wear ratios in their upper first incisors and their upper canines. Additionally, all of the upper anterior teeth in the male group have larger inter-quartile ranges. For the cheek teeth the wear patterns are very similar with only a few wear ratios rising above the first molar line in the premolars. The males also have a larger inter-quartile range in their fourth premolars.

Site	Location	Number of specimens	Male	Female	Sex ind. or unknown
Bidstrup	Scandinavia	2	1	-	1
Borreby	Scandinavia	9	5	4	-
Juelsberg	Scandinavia	2	1	-	1
Kyndeløse	Scandinavia	8	4	4	-
Rævehøj	Scandinavia	4	2	2	-
Svinø	Scandinavia	1	-	1	-
Uggerselvgaard	Scandinavia	2	1	1	-
Abou Gosh	W. Asia	6	2	-	4
Atlit Yam	W. Asia	8	1	1	6
Hatoula	W. Asia	6	3	3	-
Total		48	20	16	12

Table 8.7.1: Neolithic specimens included in the current study, divided geographical location and sex.

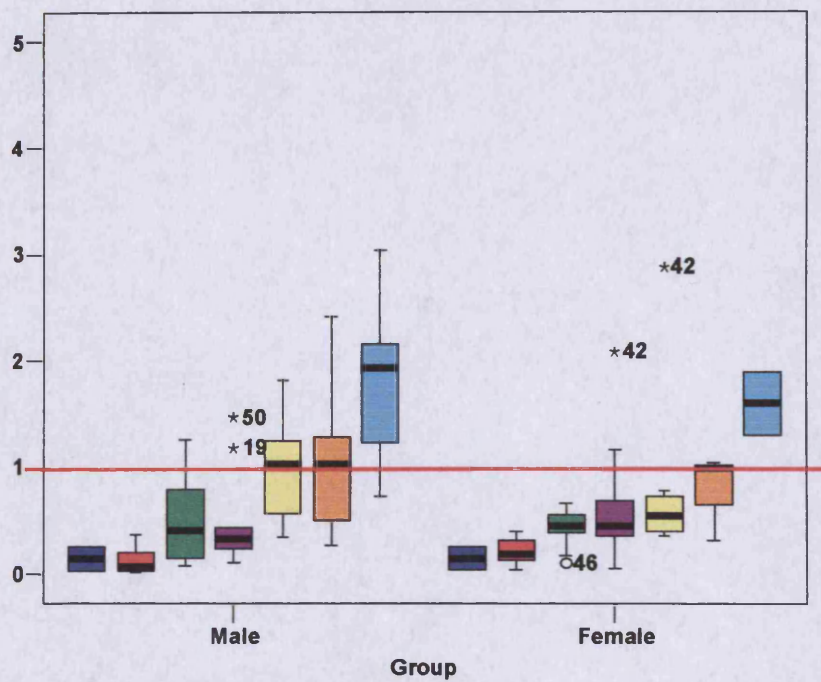


Figure 8.7.3: Male and female Neolithic MH wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

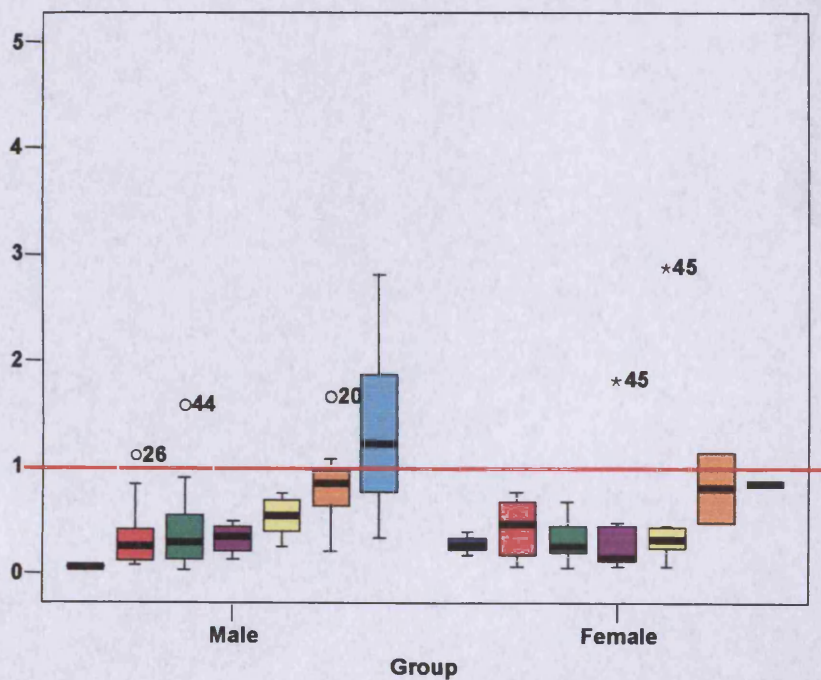


Figure 8.7.4: Male and female Neolithic MH wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

The male and female Neolithic Modern Humans show more contrasting wear in their lower dentitions. The numbers of dentitions in the female group are low, however, limiting the conclusions which can be drawn. Their wear ratios all fall within the range of the male incisors. In the male group, both premolars show higher median wear ratios than the second molars, while the opposite is true for the female group. In fact, the median wear ratio for the third premolars is lower than that of the third molars in the female group.

Neolithic Modern Human sites compared (Figs. 8.7.5 & 8.7.6)

The Neolithic Modern Humans were divided into two groups based on their European or Asian origin, to assess whether any possible regional variations in resource availability had an effect on their tooth wear patterns (Table 8.7.1). In the upper dentition, the pattern of wear ratios differs between the Asian and European groups with higher median wear ratios in the Europeans. This is particularly apparent in the second incisors and canines, which have median wear ratios over twice those from the Asian group. In fact, the second incisors have a notably low median wear ratio. The premolars also have noticeably higher median wear ratios on the European group with larger inter-quartile ranges.

In the lower dentition, the Asian and European Neolithic Modern Humans show a more similar pattern of wear. The exceptions are the upper first incisors for which the median wear ratio is much higher in the Asian Neolithic Modern Humans. In addition, the median wear ratios of the second incisors and third premolars are slightly higher in the European group. The second molar median wear ratio is, however higher in the Asians.

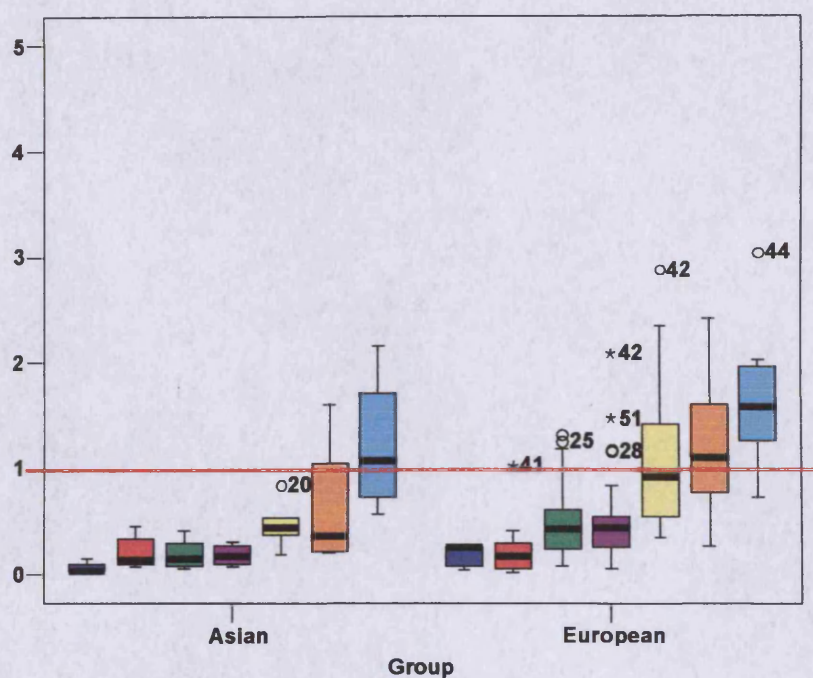


Figure 8.7.5: Neolithic MH wear ratios plotted separately by region, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

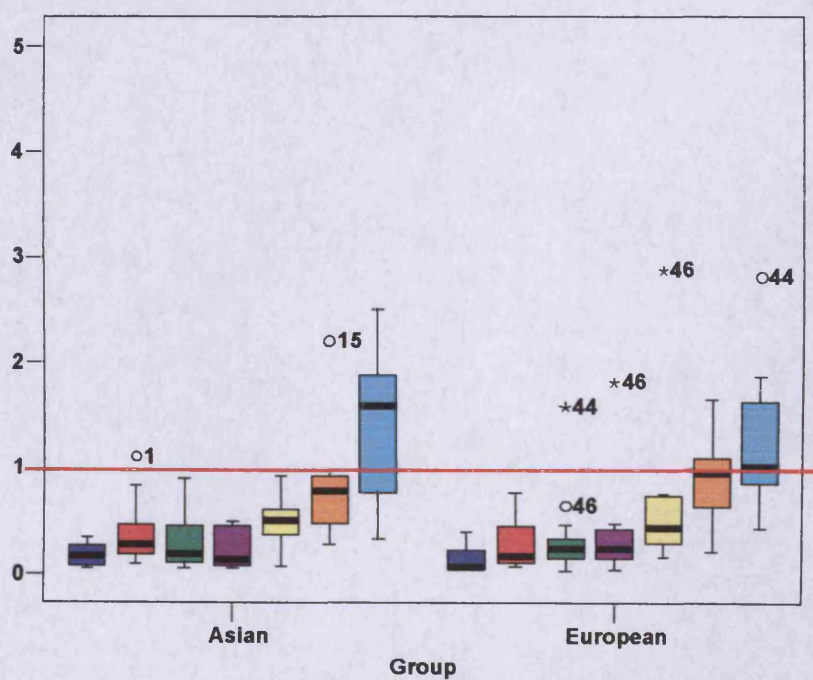


Figure 8.7.6: Neolithic MH wear ratios plotted separately by region, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

Late Epipalaeolithic, Mesolithic and Neolithic Modern Humans compared (Figs. 8.7.7-8.7.9)

In the upper dentition, the pattern of wear ratios differs between the Late Epipalaeolithic, Mesolithic and Neolithic Modern Humans. The biggest difference can be seen in the anterior teeth, where all the anterior teeth from the Mesolithic Modern Human group possess a median wear ratio above the first molar line. In the Late Epipalaeolithic group both the upper incisors show median wear ratios which fall above the first molar line; while in the Neolithic group only the first incisor has a median wear ratio above this line. In addition, the upper third premolars from the Mesolithic group possess a median wear ratio which falls above the first molar line. For the cheek teeth, the wear ratios within the Neolithic group are the lowest and most closely resemble the pattern expected from the eruption sequence. The Mesolithic Modern Humans possess high wear ratios for their premolars compared to the other two groups and the Late Epipalaeolithic Modern Humans possess the largest inter-quartile ranges for their second and third molars.

In the lower dentition, the Late Epipalaeolithic, Mesolithic and Neolithic Modern Humans also show contrasting patterns of wear. The Neolithic Modern Human lower dentition show median wear ratios which approach that expected from their position in the eruption sequence, with only the first incisor showing a median wear ratio above the first molar line. Out of the three groups the Mesolithic Modern Humans possess the highest median wear ratios for their second molars and premolars, with slightly large inter-quartile range. All of their teeth possess median wear ratios which fall on or below the first molar line, in contrast to the Late Epipalaeolithic Modern Humans whose incisors possess median wear ratios which rise above the first molar line. The cheek teeth from the Late Epipalaeolithic and Neolithic Modern Humans possess similar median wear ratios and inter-quartile ranges.

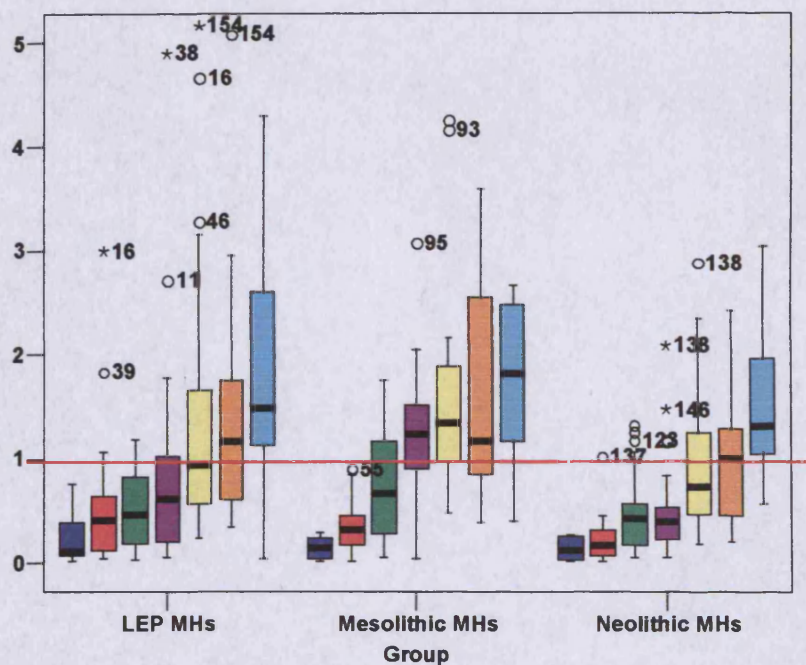


Figure 8.7.7: Late Epipalaeolithic, Mesolithic and Neolithic MH wear ratios plotted separately, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

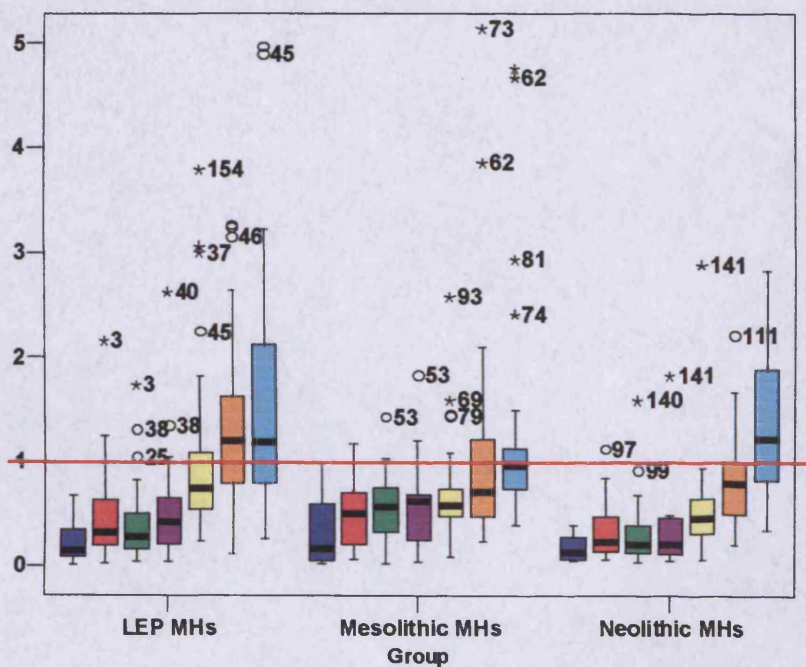


Figure 8.7.8: Late Epipalaeolithic, Mesolithic and Neolithic MH wear ratios plotted separately, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

8.8 Combined Groups

The wear ratios for each hominin group are combined on a single graph for both the upper and lower dentition, to summarise variation in wear patterns between groups.

Upper dentition (Figs. 8.8.1 & 8.8.2)

In the upper dentition, the Inuit show strikingly higher wear ratios for their anterior teeth, with median wear ratios of between two and eight times those of the other hominin groups. The Upper Palaeolithic/Early Epipalaeolithic Modern Humans possess the largest inter-quartile range for their upper first incisors, although this has largely been attributed to specimens from a single Upper Palaeolithic/Early Epipalaeolithic site (see section 8.4 for further discussion). In all the hominin groups, except for the Late Epipalaeolithic and Neolithic Modern Humans, the median wear ratios for each of the anterior teeth lie above the first molar line. The Neanderthals, Middle Palaeolithic Modern Humans and Inuit show the heaviest patterns of wear in their anterior teeth, relative to the first molar, whilst in other groups such as the Upper Palaeolithic/Epipalaeolithic Modern Humans only the upper first incisors possess noticeably high wear ratios.

The Neanderthal anterior teeth show a unique pattern of wear. In all other hominin groups there is some differentiation between the wear ratios of the anterior teeth, with the first incisors generally being the most heavily worn, relative to the first molar, followed by the second incisors, and then the canines. Contrastingly the Neanderthal upper anterior teeth possess very similar median wear ratios and inter-quartile ranges.

In three of the groups, the Neanderthals, Upper Palaeolithic/Early Epipalaeolithic Modern Humans and Inuit, the third premolars are at the cross over point of the graph between those teeth with wear ratios greater than one (mostly anterior) and those less than 1. The canines and third premolars hold this position in the Middle Palaeolithic Modern Humans and the canines and second incisors in the Neolithic Modern Humans, while in the Late Epipalaeolithic Modern Humans it lies between the first and second incisors and between the premolars in the Mesolithic Modern Humans.

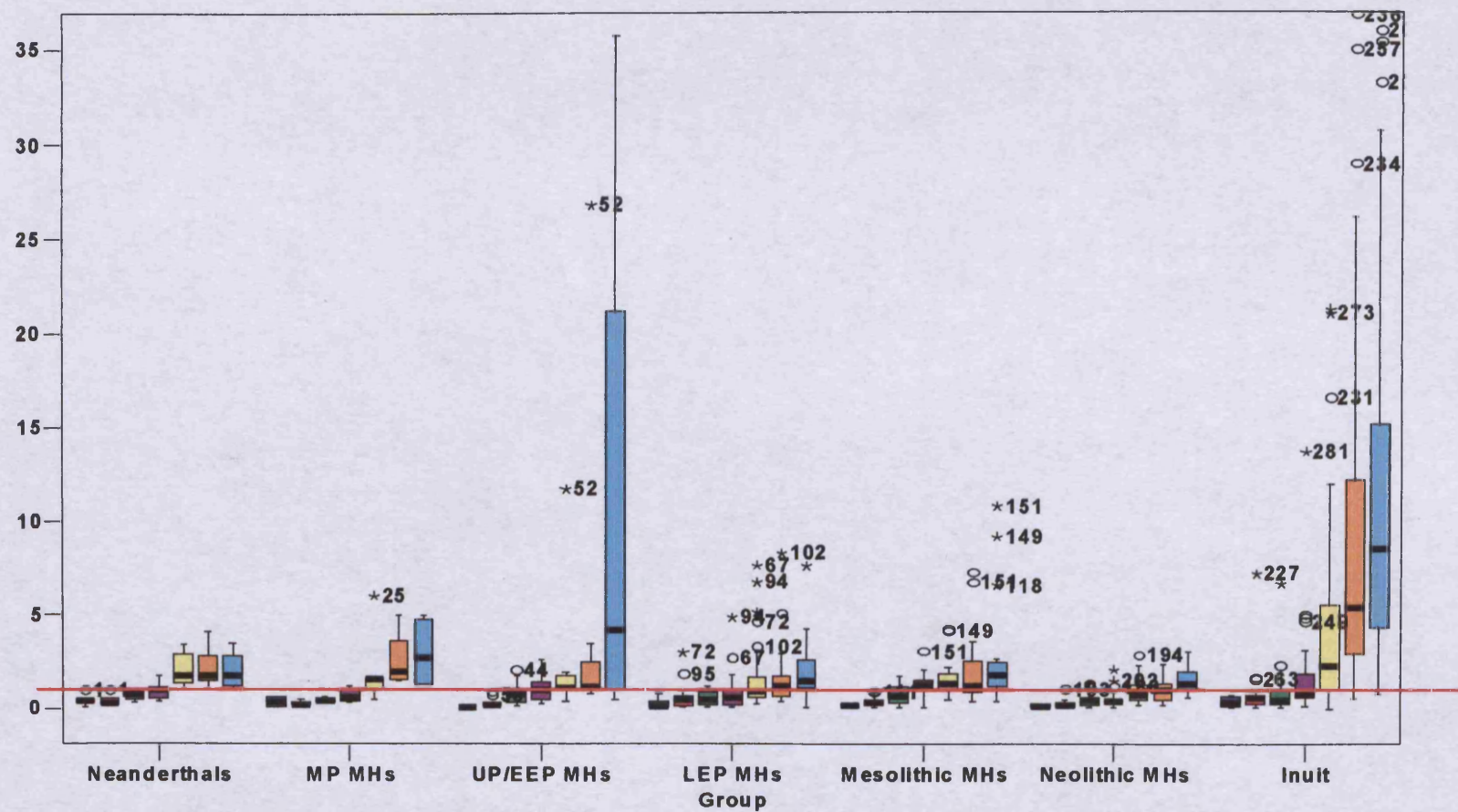


Figure 8.8.1: Hominin wear ratios plotted separately by cultural group, relative to the first molar, for the upper dentition (scale reduced to 0-35 to include all boxplots). For axis labels and key see Fig. 8.1.6.

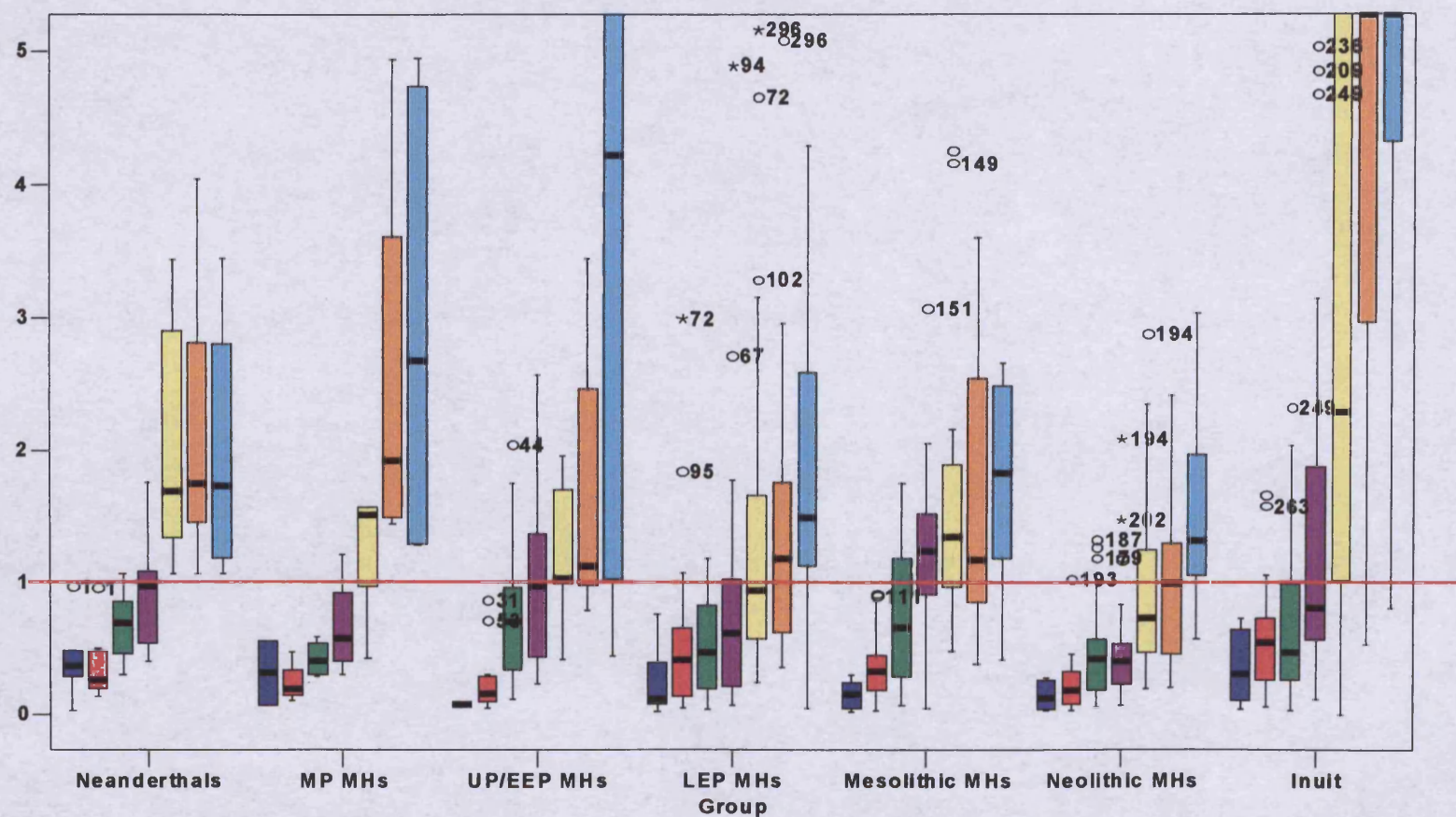


Figure 8.8.2: Hominin wear ratios plotted separately by cultural group, relative to the first molar, for the upper dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

In contrast to the anterior teeth, the upper cheek teeth, apart from the fourth premolars in the Mesolithic group, all have median wear ratios which fall on or below the first molar line. Both the premolars show noticeably heavier wear patterns than the second and third molars, relative to the first molar, in the Neanderthals, Upper Palaeolithic/Early Epipalaeolithic Modern Humans and the Mesolithic Modern Humans. The upper third molars are also more heavily worn, relative to the first molar, than the second molars in the Neanderthals and Middle Palaeolithic Modern Human groups.

Lower dentition (Figs. 8.8.3 & 8.8.4)

In the lower dentition, the pattern of wear ratios varies strongly between groups. As seen in their upper dentition, the Inuit show extremely high wear ratios for their lower anterior teeth. Both their lower incisors and canines have median wear ratios more than twice that of any other group. The Neanderthals and Middle Palaeolithic Modern Humans also possess high median wear ratios for all their anterior teeth with large inter-quartile ranges. The Upper Palaeolithic/Early Epipalaeolithic Modern Humans only show a high median wear ratio for their lower first incisors. For the lower dentition it is the Inuit and Middle Palaeolithic Modern Humans who possess the largest inter-quartile range, in both cases for their first incisors.

At the cross over point of the graph, between those teeth with wear ratios greater than one (mostly anterior) and those less than 1 are: the first incisors for Mesolithic Modern Humans; the second incisors for the Middle Palaeolithic and Neolithic Modern Humans; between the second incisors and canines for the Late Epipalaeolithic Modern Humans; between the canines and third premolars for the Neanderthals and Upper Palaeolithic/Early Epipalaeolithic Modern Humans, and between the premolars for the Inuit.

All of the lower cheek teeth, apart from the lower third premolars in the Inuit group, have median wear ratios which fall below the first molar line. The lower cheek teeth show a more similar pattern of wear when compared to the lower anterior teeth with smaller inter-quartile ranges. Out of all the cheek teeth the lower third premolars have the highest median wear ratio, relative to the first molar, in all of the groups, apart from the Neolithic Modern Humans where the second molars have the highest median wear ratio. The Mesolithic Modern Humans possess the highest overall wear pattern in their lower cheek teeth, which apart from the third molars have similar median wear ratios. The third molars have the lowest median wear ratio in each group, as expected from the eruption sequence.

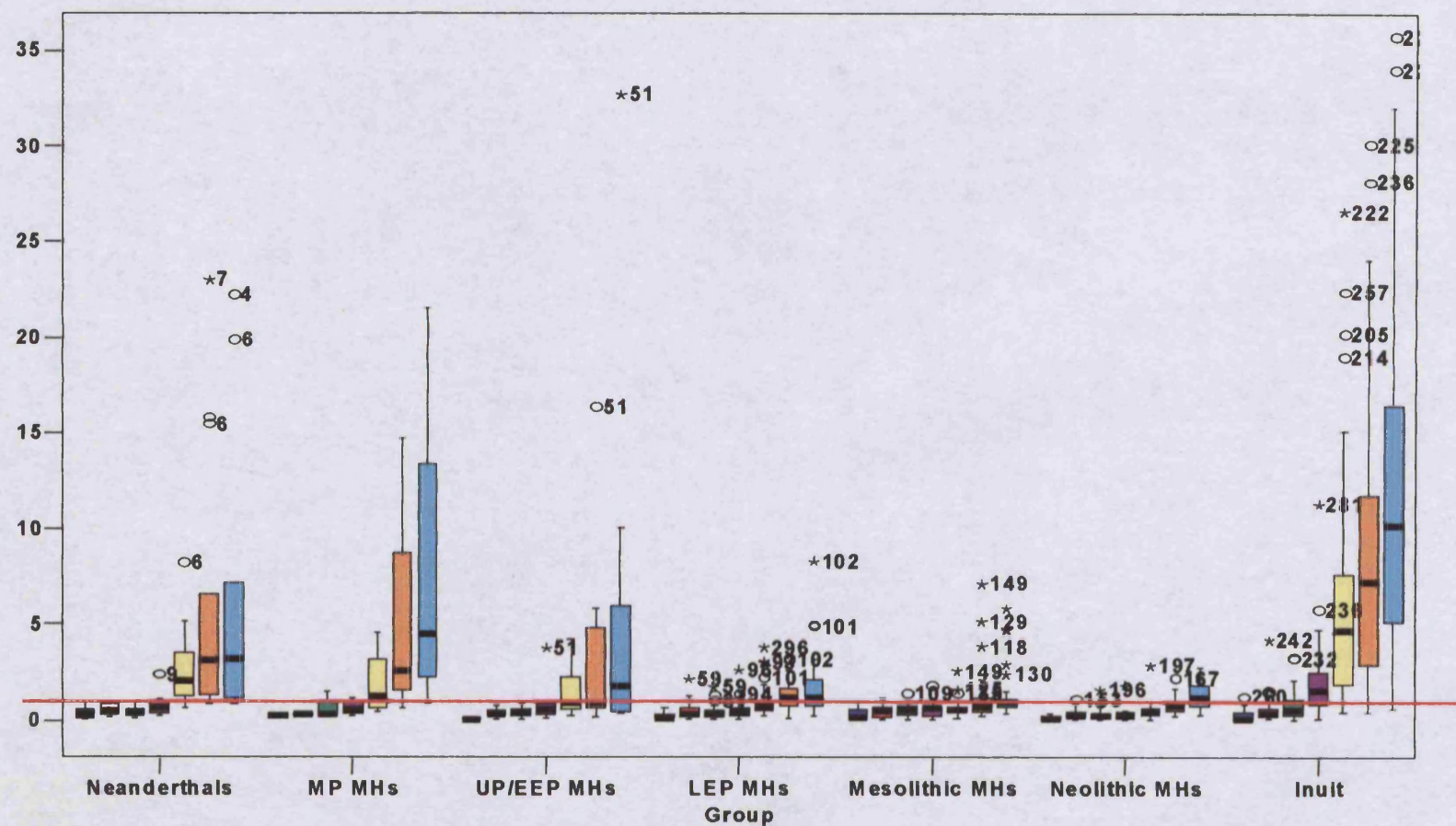


Figure 8.8.3: Hominin wear ratios plotted separately by cultural group, relative to the first molar, for the lower dentition (scale reduced to 0-35 to include all boxplots). For axis labels and key see Fig. 8.1.6.

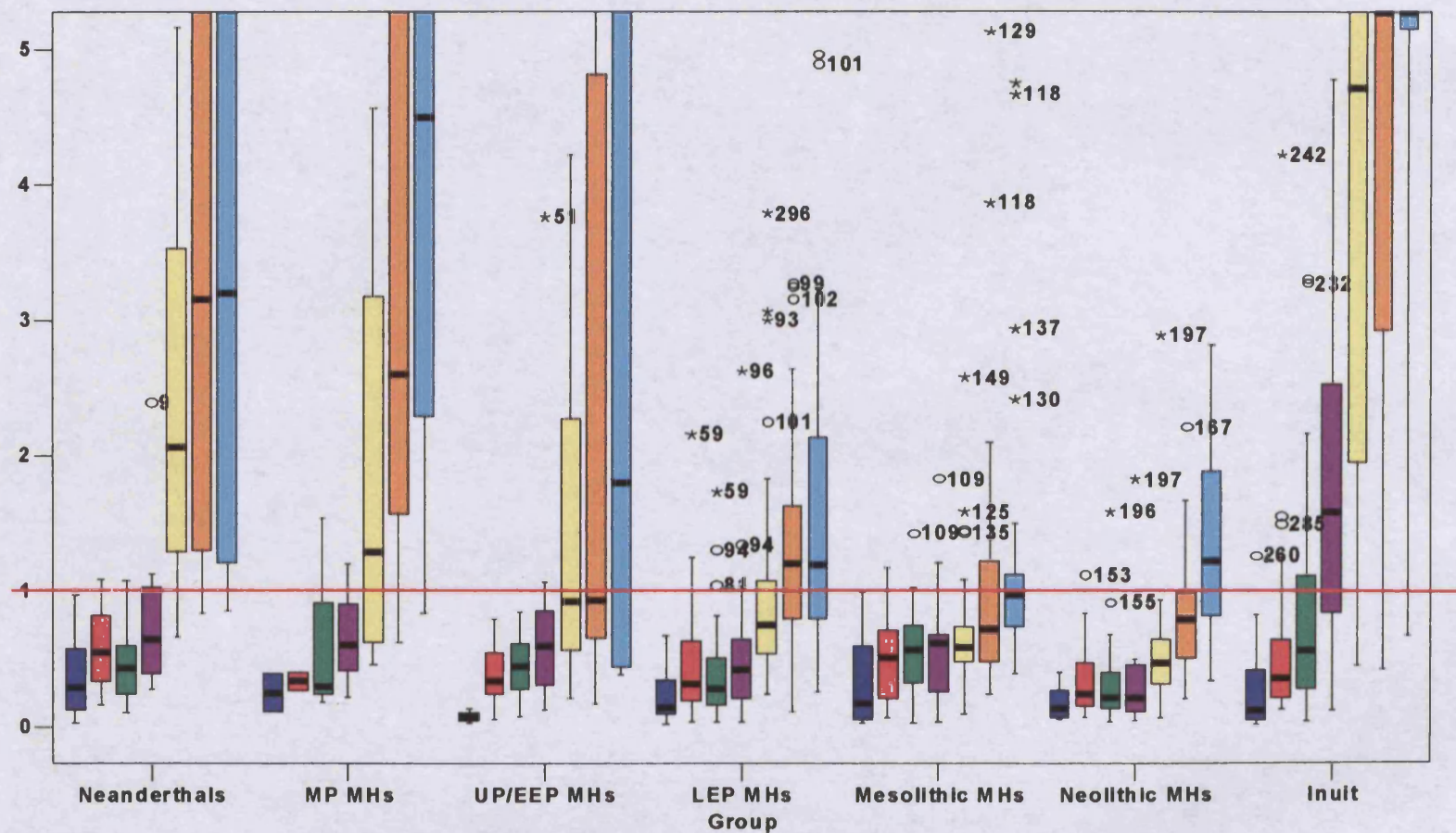


Figure 8.8.4: Hominin wear ratios plotted separately by cultural group, relative to the first molar, for the lower dentition (standard scale 0-5). For axis labels and key see Fig. 8.1.6.

Summary

The Inuit show extremely high wear ratios for their upper and lower anterior teeth with a large overall range in wear values. The Neanderthals and Middle Palaeolithic Modern Humans also show patterns of heavy anterior wear in both their upper and lower dentitions, but this is dwarfed by the wear shown by the Inuit. The Upper Palaeolithic/Epipalaeolithic Modern Humans possess high median wear ratio for their upper and lower first incisors, while the Late Epipalaeolithic and Mesolithic Modern Humans possess higher median wear ratios in the upper dentition than in their lowers. For the cheek teeth, there is much less variation between the hominin groups. Overall, the Mesolithic Modern Humans have some of the highest median wear ratios for their upper and lower cheek teeth. The upper and lower premolars have high median wear ratios in the Neanderthals, Upper Palaeolithic/Early Epipalaeolithic Modern Humans and the Inuit. The upper and lower third molars generally possess the lowest wear ratios, as expected from the eruption sequence.

Overall, the wear patterns exhibited by the Neolithic Modern Humans most closely resemble the expected pattern from the eruption sequence, and those of the Inuit differ the most.

Chapter 9 - Discussion

Four research questions were proposed in Chapters 1 and 5. Each question was accompanied by several predictions and hypotheses. Using the results outlined in Chapter 8, each of these four questions can now be addressed.

9.1 - Neanderthals possessed a unique facial and dental morphology which has often been explained by heavy dental loading on the anterior teeth and jaw. Most observers support this argument by pointing to the heavy wear of Neanderthals' anterior teeth, but is this wear exceptional when compared with that of other later Pleistocene hominins?

The 'Anterior Dental Loading Hypothesis' maintains that the high magnitude of forces, resulting from masticatory and cultural use of the anterior teeth, led to the development of the Neanderthals' unique facial anatomy (Brace, 1995;Demes, 1987;Rak, 1986;Smith, 1983). From this theory it was predicted above that the amount of wear present on the anterior teeth would exceed that present on the first molars and indeed on all of the other cheek teeth. Furthermore, comparisons with other groups of hominins with different facial morphologies would show this pattern of heavy anterior wear to be either unique to the Neanderthals or developed most strongly.

Almost all of the Neanderthal specimens included in this study possessed heavy anterior wear, with higher wear ratios than the first molars and all other cheek teeth. The upper anterior teeth all had similarly high median wear ratios, large inter-quartile ranges and overall ranges in values. In fact, all of the specimens examined demonstrated higher wear ratios in the upper anterior teeth than the first molars. For the lower dentition, the incisors and canines possessed even higher median wear ratios and larger inter-quartile ranges than their upper counterparts. The median wear ratios of the lower incisors were three times that of the first molar, while that of the canine was twice that of the first molar. There was, however, a greater difference in wear ratios between the lower anterior teeth, with the canines possessing a lower median wear ratio and a smaller inter-quartile range than both of the incisors.

Most of the later erupting cheek teeth were less worn than the first molars, as would be expected from their eruption timing. The upper third premolars were the exception, with almost half the Neanderthal specimens showing wear ratios greater than first molars.

These results show that the Neanderthal specimens included in this study possessed a pattern of heavy anterior wear in both the upper and lower dentitions. They did, however, inhabit a large geographical area over a long chronological period. It is therefore important to determine whether tooth wear patterns varied between regional and chronological groups. The Neanderthal specimens were divided into two geographical regions, Europe and Western Asia, and two chronological periods, pre- and post-50,000 BP (see Chapter 8.1). The Neanderthal specimens were divided into two geographical regions, Europe and Western Asia, and two chronological periods, pre- and post-50,000 BP. These divisions were made to see whether the regional availability of resources had an impact on the Neanderthal wear pattern and whether this pattern changed over time.

Overall the European and Asian Neanderthals showed similar wear patterns in their upper dentition, although the Asian Neanderthals possessed a higher median wear ratio for their upper canines than the Europeans. In addition, the European Neanderthals showed a higher median wear ratio for their upper third premolars and it was this that was mostly responsible for the raised values in the Neanderthals as a whole (above). There were greater differences in the lower dentitions, with the European Neanderthals possessing higher median wear ratios and larger overall ranges than the Asians. The largest difference was observed in the anterior teeth, with strikingly higher median wear ratios for the European Neanderthals and larger inter-quartile ranges. This was contrasted with the Asian Neanderthals, which possessed median wear ratios for the anterior teeth that lay just above the first molar line. The European Neanderthals also displayed a higher median wear ratio for the lower third premolars than the Asians. These higher wear ratios for the lower anterior teeth appear to have been particularly influenced by the Neanderthals from the site of Krapina, Croatia. In the combined Neanderthal graph for the lower dentition, most of the Krapina anterior wear ratios were represented by outliers; some as high as 15 and 22. These were included within the inter-quartile ranges when the European group was plotted on its own.

The division into pre- and post-50,000 BP also showed some marked differences in wear patterns. The Neanderthals from sites dated to post-50,000 BP showed higher median wear ratios for their upper incisors, but a lower median wear ratio for the upper canine than those dated to pre-50,000 BP. The lower anterior teeth showed much higher median wear ratios in the pre-50,000 BP than the post-50,000 BP groups. Again this was mainly due to the extremely high wear ratios shown by the specimens from Krapina. The Neanderthals from sites dated to pre- and post-50,000 BP showed more similar patterns of wear in the cheek teeth, with only the upper third premolars possessing a notably higher median wear ratio in the pre-50,000 BP group.

Differences in wear patterns have also been noted between males and females within modern hunter-gatherer populations (Drier, 1994; Molnar *et al.*, 1983b; Richards, 1984). It was therefore important to investigate whether the pattern of heavy anterior wear varied between male and female Neanderthals. Where known, the Neanderthal specimens were divided into male and female groups based upon evidence from the published literature. Notwithstanding low numbers in both the male and female Neanderthal group, resulting from the inability to determine the sex of certain specimens, interesting results emerged. The female Neanderthals possessed higher median wear ratios for both the upper and lower anterior teeth than the males (Figs. 7.1.5 & 7.1.6). The female lower anterior teeth median wear ratios were over two times those of the males. By contrast, most of the females' cheek teeth possessed wear ratios that fell within the inter-quartile ranges of the males. The exception to this was the lower third premolars, which, in the females, possessed a much higher median wear ratio.

All Neanderthal specimens included in this study, whether male or female, Asian or European, or early or late, exhibited a pattern of heavy anterior tooth wear, relative to the rest of the dentition, that was considerably greater than would be expected from the eruption sequence. In general, the lower anterior teeth displayed higher wear ratios than the upper anterior teeth, and the upper third premolars higher wear ratio values than the other cheek teeth. If the pattern of wear reflects the pattern of forces applied by the dentition, then it seems reasonable to suggest that the heaviest forces were applied by Neanderthals in the anterior part of their dentitions, including incisors, canines and third premolars. The contrast between anterior and posterior tooth wear was, however, less in the lower dentitions of the Asian Neanderthals, as opposed to European, and specimens with a later date (post-50,000 BP). These two observations are partly related to the inclusion of the Krapina specimens in the 'early' and 'European'

groups. They included individuals with particularly large and robust teeth and jaws (Wolpoff, 1979). It is therefore possible to suggest a link between robustness of face, jaws and teeth, and the degree of contrast in anterior versus cheek tooth wear. Furthermore, that robust jaws had a selective advantage in the requirement for large anterior forces, as shown by the wear patterns. Recent studies by orthodontic practitioners, such as Corruccini (1999), showed that jaw morphology also responds to the forces acting on the teeth during an individual's lifetime, suggesting that jaw morphology might also be affected by the habitual use of forces through development and adult life.

Although these results appear to confirm that Neanderthals were exerting strong forces on their anterior teeth, the Anterior Dental Loading Hypothesis further predicts that only Neanderthals would show this pattern of heavy anterior wear, or at least that it would be markedly heavier than that observed in any other hominin. However, the results of this study showed that the Neanderthal specimens were neither unique, nor showed extreme anterior tooth wear. Middle Palaeolithic Modern Human specimens from Qafzeh and Skhul showed higher median wear ratios than the Neanderthals in the upper incisors and lower first incisors, with large inter-quartile ranges. These results are discussed further in section 8.3, but it would seem reasonable to suggest that these hominins were also habitually applying forces between their anterior teeth that were at least as high as those applied by Neanderthals. The 'Anterior Dental Loading Hypothesis' could be taken to predict that there should therefore be some similarities in the morphology of their teeth, jaws and face. Whilst more robust than Upper Palaeolithic Modern Humans, the Qafzeh and Skhul specimens lack key Neanderthal features, such as a large nasal aperture, swept back zygomatic arches and a retromolar space in the mandible, along with a prominent mental eminence and somewhat reduced brow ridges. The morphology is still distinctive, however, with large teeth in robust jaws and a heavily buttressed face that differs markedly from later Modern Humans. It is therefore possible that the morphology represents an adaptation of a different kind in supporting the teeth under the application of heavy loads. This is undermined by the observation in this study that Upper Palaeolithic and Early Epipalaeolithic Modern Humans also showed evidence of heavy anterior tooth wear, relative to the cheek teeth. The pattern is slightly different to the Middle Palaeolithic Modern Humans, being mainly concentrated in the first incisors, but suggests that these later Modern Humans were able to apply heavy forces with their anterior dentition without any of the facial morphologies that characterise either group of Middle Palaeolithic hominins.

One distinguishing feature of Neanderthal tooth wear, often noted in the literature, is the rounding of the incisors on their labial surfaces (Ungar et al., 1997). This has even been noted on deciduous incisors, such as La Quina. In the present study, which is based on the occlusal surface wear of the permanent dentition, the most distinguishing feature of Neanderthal anterior tooth wear was its relatively even spread between the anterior teeth, including the canines. The most distinguishing feature of Neanderthal anterior tooth wear is that it is relatively evenly spread between the anterior teeth, including the canines. The shape of the Neanderthals' dental arcade is particularly broad in its anterior part, to accommodate large incisors and canines relative to the cheek teeth. This aspect of the facial morphology does indeed seem to match the pattern of wear, despite the lack of extreme anterior tooth wear expected through a simple interpretation of the Anterior Dental Loading Hypothesis. It seems reasonable to suggest that the selective pressure was in the application of heavy force over a broad area of anterior teeth, rather than a maximum contrast between anterior and cheek teeth.

Summary

The results of this study suggest that Neanderthals did not in fact have particularly heavy anterior tooth wear, relative to the cheek teeth. Most other Late Pleistocene hominins showed strong anterior tooth wear that in some instances exceeded that of the Neanderthals. If tooth wear does indeed reflect the magnitude of forces being placed on the dentition, then these observations do not support the idea that the Neanderthal facial morphology can be best explained as an adaptation to repeated and exceptionally strong application of force between the anterior teeth. The contrast between the anterior and cheek teeth does vary between specimens. The Asian Neanderthals, which are generally less robust than the Europeans (particularly the robust specimens from Krapina), show a smaller contrast in wear ratios between the lower anterior and cheek teeth. Earlier Neanderthals (pre-50,000 BP), again including the specimens from Krapina, show greater contrast between wear ratios in their lower anterior and cheek teeth than later specimens. This suggests that the contrast between the anterior and cheek teeth varies with the robustness of the skull, jaws and faces – the more robust the greater the contrast between the anterior and cheek teeth. However, those specimens which have been designated female (on the basis of a more gracile skull morphology) show a greater contrast in wear between their anterior and cheek teeth than the males.

The main feature of tooth wear that seems to distinguish Neanderthals from other groups of hominins is not the degree of contrast between anterior and cheek teeth, which is unexceptional, but in the more even spread of tooth wear between first incisors, second incisors and canines. This is matched by a particular Neanderthal facial morphology – the broad anterior part of the palate associated with relatively large incisors and canines.

9.2 - The stocky body proportions of recent Inuit from Alaska, Canada and Greenland are often used as supporting evidence for the idea that Neanderthals were cold-adapted. The robust jaws and exceptionally heavy tooth wear of Inuit hunter-gatherers have also been seen as comparable to those of Neanderthals. Is recent Inuit tooth wear a good model for understanding Neanderthal tooth wear?

The Inuit of Alaska, Canada and Greenland have frequently been used as a model for understanding Neanderthal behaviour and biology. Heavy anterior tooth wear, frequently observed within the dentitions of Inuit hunter-gatherers, echoes that of the Neanderthals. Inuit hunter-gatherers share with Neanderthals a strongly developed masticatory musculature in the anatomy of their skulls and jaws, with features such as incisor shovelling also suggesting an increased strength in their teeth (Bailey, 2002; Bang and Hasund, 1971; Demes, 1987; Hylander, 1977; Leigh, 1925; Mayhall and Kanazawa, 1989; Pedersen, 1947; Rak, 1986; Ungar *et al.*, 1997). These similarities have led to the assumption that Inuit and Neanderthal teeth were used to perform similar tasks. Whilst relatively little is known about the cultural use of the teeth in the Neanderthals, much more is known about the Inuit from the ethnographic literature (see chapter 7.7). However, the relationship between Inuit and Neanderthal tooth wear has, until now, never been formally measured.

The results from Chapter 8.2 showed that, in both the upper and lower dentition, the Inuit of Igloolik exhibited a pattern of extremely heavy anterior wear, relative to the first molar and other cheek teeth. The upper anterior teeth possessed median wear ratios of between 2 and 8, while the lower anterior teeth's were even higher, between 5 and 10. They also displayed much larger inter-quartile ranges and overall ranges in wear ratios than the cheek teeth. Most of the cheek teeth possessed wear ratios less than that of the first molar, with only the upper inter-quartile ranges of the third premolars

and lower fourth premolars being greater than 1, and that of the lower third premolars being the highest.

Although both groups exhibited a pattern of heavy anterior tooth wear, Neanderthal anterior wear was dwarfed by that of the Inuit from Igloolik. The biggest difference was shown in the incisors, with the Inuit possessing median wear ratios that were between three and four times those of the Neanderthals. They also possessed larger inter-quartile ranges and overall ranges in wear ratios. However, the anterior wear was more evenly spread in the Neanderthals than in the Inuit of Igloolik. The cheek teeth displayed more similar patterns of wear between the two groups, although the Inuit possessed slightly larger inter-quartile ranges and overall ranges in wear ratio values than the Neanderthals. Of the cheek teeth, the third premolars displayed the biggest difference in wear ratios; the Neanderthals possessing a higher median wear ratios for the upper third premolars and the Inuit a higher median wear ratio for the lower third premolars.

If tooth wear reflects the magnitude of forces being placed on the dentition then the extremely high wear ratios displayed by the Inuit of Igloolik suggest that they were subjecting their anterior teeth to much stronger or more repetitive forces than the Neanderthals. This questions the assumption that their teeth were used to perform similar tasks. Further comparisons with other hominin groups confirmed that the level of anterior tooth wear, in relation to their cheek teeth, displayed by the Inuit of Igloolik was exceptional. This exceptionally heavy anterior tooth wear can best be explained in relation to the extreme and marginal environments in which they lived. In the arctic, resources would have been limited, with very little plant life surviving, and their environment provided them with a very limited tool kit. The low temperatures would also have favoured the use of the teeth to perform certain tasks before removing the hands from warm gloves. Anecdotal evidence supports this with observations of Inuit males using their teeth, rather than their hands, to retrieve hunted seals from icy waters (Mayhall, 1972). This combination of factors would have meant that the teeth provided the Inuit with a constantly available tool that could be used for a number of different tasks. Accounts by anthropologists and early explorers noted the use of the Inuit anterior teeth for tasks such as softening raw seal hide, as a third hand for holding and untangling dog sled traces, adapting animal sinew into useful thread, pulling lines tight, sewing, and more recently as a vice and for opening oil drums (Davies and Pedersen, 1955; Leigh, 1925; Mayhall, 1970; Mayhall, 1972; Mayhall, 1977; Pedersen, 1947; Waugh, 1937). Their diet, which consisted primarily of fats and meat protein, would have

required limited mastication (Davies and Pedersen, 1955; Pedersen, 1947), so it appears that the other uses to which their teeth were put were responsible for their extensive tooth wear.

The crania of both Neanderthals and Inuit of Alaska, Canada and Greenland show evidence of a strongly developed masticatory musculature and shovelling in their incisors, which in the Inuit has been linked to the generation and dissipation of large biting force (Bailey, 2006; Bang and Hasund, 1971; Hylander, 1977; Molnar, 1972; Pedersen, 1947). The evidence from the Inuit tooth wear patterns supports this theory.

When all these factors are taken into account it seems unsurprising that the Inuit of Igloodik represent such an extreme case, using their teeth for a much greater number of tasks, and more frequently, than would be predicted for Late Pleistocene hunter-gatherers living in warmer environments with access to a much more diverse tool kit. The Inuit of Alaska, Canada and Greenland may therefore not represent a direct model for understanding Neanderthal tooth wear patterns but do, nonetheless, provide us with a wealth of information for understanding more general aspects of hunter-gatherer tooth wear. A good example of this is to be found in the differences between male and female tooth wear patterns. From ethnographic literature we know that it was predominantly the Inuit females who used their anterior teeth to soften raw seal hide (Leigh, 1925; Pedersen, 1947; Waugh, 1937). This involved chewing and pulling the hide of an animal, such as a seal or caribou, between the front teeth in a downward motion. The wear ratios for the Inuit from Igloodik were divided into male and female groups and the results showed notable differences between their wear patterns. Inuit females showed higher and more variable wear ratios than the males in their anterior teeth, with median wear ratios between two and three times those of the males in their upper anterior teeth. The cheek teeth showed a more similar pattern of wear between the sexes, apart from the third premolars and upper third molars, which possessed higher median wear ratios in the females with larger inter-quartile ranges.

These results suggest that the heavier anterior tooth wear displayed by the Igloodik females was primarily the result of softening raw seal hide, an activity that was regularly performed to produce clothing and was highly abrasive (Leigh, 1925). The higher wear ratios found in the females' third premolars suggest that these teeth were also involved (presumably this is related to size of the mouth opening). Furthermore,

studies of the Inuit cranial morphology have shown that females possessed a more powerful masticatory musculature than males (Leigh, 1925).

Similarly, the female Neanderthals displayed higher median wear ratios in the anterior teeth than the males, with median wear ratios in their upper anterior teeth over twice that of the males. They also showed higher wear ratios than the males for their third premolars. The evidence from the Inuit of Igloodik suggests that this might also have been the result of sexual division of labour amongst the Neanderthals, with the females generating greater or more repetitive forces between their anterior teeth. The size of the female Neanderthal group examined was, however, small and would need to be increased before any firm conclusions can be drawn. Male Neanderthals, however, possess a more robust facial morphology and greater developed masticatory muscles than females. This is a paradox that is difficult to explain. The lack of well preserved pelvises has meant that most Neanderthals were assigned a sex based upon their relatively robust or gracile skeletal morphologies.

The Neanderthals and the Inuit of Igloodik both possessed higher wear ratios for their lower anterior teeth than for their uppers. The ethnographic literature for the Inuit suggests that this may, once again, have been the result of activities such as the softening of raw seal hide, which was pulled through the anterior teeth with a strong downward force. This would have placed higher forces on the lower teeth leading to an increase in tooth wear. A similar explanation may also be proposed for this difference in Neanderthal wear patterns. The widely reported rounding of the incisors on their labial surfaces, observed within both Neanderthal and Inuit dentitions, provides further support for this type of activity (Leigh, 1925; Puech, 1981; Ungar *et al.*, 1997).

Age must be an important factor in the development of tooth wear patterns, but there have rarely been any opportunities to examine this in high wear rate populations. The Inuit of Igloodik were divided into five categories based upon their reported age at the time of dental impressions (see Chapter 8.2). The overall pattern of heavy anterior wear, relative to the cheek teeth, was the same for all age categories, but appeared to decrease slightly as age increased, with individuals from the 21-30 and 31-40 age groups possessing the highest wear ratios for their anterior teeth. The first incisors displayed the largest difference in wear ratios between the age categories, with median wear ratios for the 21-30 and 31-40 age groups almost double those from the 41-50 and 51-60 age groups. A much smaller difference was seen in the second incisors and canines. Initially, these results suggested that more pronounced anterior tooth wear,

especially in the first incisors, was present in younger individuals within this population. However, it might also be explained by small group sizes in the older age categories; the 51-60 and over 60 age categories contained the lowest number of individuals, limiting the range in their wear ratio values. Furthermore, the Inuit of Igloodik wore their anterior teeth at a fast rate, causing the dentine proportions for the anterior teeth to reach 1 by age 40, allowing the dentine proportions of the cheek teeth to catch up. This is supported by the pattern of wear shown by the lower third premolars, which emerge much later than the incisors in the eruption sequence and possessed a similar median wear ratio in all of the age categories (apart from the over 60s). In fact, the 51-60 age group possessed the highest median wear ratio for this tooth.

The Neanderthals were divided into two age categories, mostly based upon the information provided in the published literature: 25 years and under, and over 25. These two age categories were selected as human skeletons can be relatively reliably placed in either category based on the state of eruption of the third molar and/or the fusion of epiphyses in the skeleton. This made it more likely that different studies would be consistent. The upper dentitions for these two groups showed similar wear patterns, with the canines and third premolars possessing a higher median wear ratio in the over 25 age group. More discernible differences were found within the wear patterns of the lower dentition, with the 25 and under age group displaying much higher median wear ratios for the anterior teeth than the over 25 age group. This group was, however, dominated by Neanderthal specimens from the site of Krapina, all of which were aged below 25 and possessed high wear ratios. Differences in Neanderthal tooth wear patterns, therefore, seem more influenced by region and chronological date of the specimens than their age.

The high wear ratios displayed by the Krapina Neanderthals in their anterior teeth, which appeared as outliers in the combined Neanderthal graphs, would have fitted within the Inuit of Igloodik wear pattern. This suggests a particularly heavy reliance on the anterior teeth as tools within this group of Neanderthals. The archaeological evidence from this site includes a number of exotic materials, which Simek (1990) suggested was evidence of a highly mobile lifestyle. Whilst moving throughout the Neanderthal landscape the teeth would have provided a highly portable and diverse tool.

Summary

The Inuit of Igloolik displayed exceptionally high wear ratios for their anterior teeth, relative to the cheek teeth when compared to both Neanderthals and all other hominin groups included in this study. These high wear ratios can be associated with ethnographic evidence for the intensive use of the anterior teeth to generate strong forces when performing activities such as softening raw seal hide. As the results suggest that the Inuit of Igloolik were subjecting their anterior teeth to much higher or more frequent forces than the Neanderthals, they do not represent a direct model for understanding Neanderthal tooth wear and behaviour. The Inuit of Alaska, Canada and Greenland lived in colder, more marginal environments than the Neanderthals, with limited resources available to them. Their limited tool kit combined with the low temperatures appears to have intensified the use of their teeth. Furthermore, these results suggest that the similarities between Neanderthal and Inuit tooth wear and use have been previously overstated. Further investigation is required to ascertain whether the exceptionally heavy anterior tooth wear pattern exhibited by the individuals from Igloolik was a common feature of all Inuit populations practising a traditional way-of-life.

Despite the extreme nature of Inuit anterior tooth wear, they still provide a useful model for understanding the more general relationship between tooth wear and cultural activities in ancient hunter-gatherers. They highlight the development of a characteristic wear pattern early during the life of a hunter-gatherer, which is largely maintained throughout life, leaving us to suppose that the variation observed in Neanderthal groups was the result of regional and chronological differences between specimens rather than their age. They also highlight the effects of sexual division of labour in cultural activities on male and female tooth wear patterns, with both the female Inuit of Igloolik and female Neanderthals possessing higher wear ratios for their anterior teeth than the males. Finally, they allow us to make connections between tooth wear and certain types of cultural tasks.

9.3 – Neanderthals and Early Modern Humans from Western Asia possessed similar Middle Palaeolithic tool kits. With a similar type of technology, it might be expected that the pattern of tooth wear would be similar in each group. Is this so, and how does this change during the Upper Palaeolithic and Early Epipalaeolithic?

Both Anatomically Modern Humans and all but the very youngest Neanderthals have been found in association with Middle Palaeolithic tool kits, showing very little variation in stone tool morphology. If their dentition formed an integral part of their tool kit, as it has often been supposed, then both groups would have been expected to have possessed similar tooth wear patterns. Equally, changes in the hominin tool kit during the Upper Palaeolithic and Early Epipalaeolithic should be associated with a change in these wear patterns. Tooth wear patterns between Neanderthals, Middle Palaeolithic Modern Humans, and Upper Palaeolithic/Early Epipalaeolithic Modern Humans were therefore compared.

These comparisons showed that, although both the Neanderthals and Middle Palaeolithic Modern Humans displayed a pattern of heavy anterior wear, relative to the first molar (see above), the Middle Palaeolithic Modern Humans showed higher median wear ratios for the upper incisors than the Neanderthals, with larger inter-quartile ranges. Both groups possessed similar median wear ratios for the upper canines, but much larger inter-quartile ranges were evident in the Neanderthals. For the lower anterior teeth, the Middle Palaeolithic Modern Humans showed a higher median wear ratio for the first incisors, while the Neanderthals showed higher median wear ratios for the second incisors. In both groups the lower anterior teeth possessed higher wear ratio values than their upper counterparts. The Neanderthals also displayed a relatively more even spread of wear in their anterior teeth. In contrast, in the Middle Palaeolithic Modern Humans, the first incisors possessed the highest wear ratios, followed by the second incisors and finally the canines.

The cheek teeth also displayed similar wear patterns in both groups, although the Neanderthals showed higher median wear ratios for the upper premolars than the Middle Palaeolithic Modern Humans. Both groups showed higher median wear ratios for the upper third molars than for the second molars. This is not what would be expected from the eruption sequence, as the third molar emerges significantly later than the second molar.

The Middle Palaeolithic Modern Human sample was comprised of specimens from the sites of Qafzeh and Skhul in Israel. As the Neanderthals displayed regional differences in their tooth wear patterns, these Middle Palaeolithic Moderns were also compared to Neanderthals only from sites in Western Asia. In this comparison the difference between them was somewhat greater. The Middle Palaeolithic Modern Humans possessed higher wear ratios for the upper first incisors and lower incisors, while the Neanderthals from Western Asia possessed a higher wear ratio for the upper canines. The cheek teeth showed a similar pattern of wear in both groups; with most wear ratios being less than those of the first molars. The high wear ratios seen in the upper premolars from the combined Neanderthal graphs were absent in the West Asian Neanderthals, which showed a similar range in wear ratios to their Early Modern Human neighbours.

As discussed in the previous section (9.1) these results suggest that the Middle Palaeolithic Modern Humans from Qafzeh and Skhul were habitually applying forces between their anterior teeth that were at least as high as those applied by the Neanderthals. These specimens possessed a more robust facial morphology than Modern Humans from succeeding cultural periods, such as the Upper Palaeolithic, but one that was very different to that of the Neanderthals. It therefore seems reasonable to suggest that morphological differences were independent of high anterior tooth wear ratios seen in these two groups of Middle Palaeolithic hominins, and further explanations need to be sought. They did show differences in spread of the wear across the anterior teeth, which was more even in the Neanderthals. This might have been related to differences in the shape of their dental arcades (see above). Ethnographic studies of modern hunter-gatherers have shown that the teeth formed an integral part of their toolkit, with the Inuit of Alaska, Canada and Greenland representing an extreme case. If this were also true of all Late Pleistocene hominins, then major changes in the hominin tool kit should be reflected in the tooth wear patterns. The Modern Humans from the sites of Qafzeh and Skhul were not only associated with a similar Middle Palaeolithic technology to most Neanderthals, but also a similar faunal assemblage to the Neanderthals from the same region. Similarities in their wear patterns could therefore be related to their tool technologies. This relationship can be tested by comparing their wear patterns with those of Upper Palaeolithic and Early Epipalaeolithic Modern Humans, which are defined by a very different and much more variable toolkit.

The Upper Palaeolithic and Early Epipalaeolithic Modern Humans did display a pattern of heavy anterior wear, but one that was different to both Middle Palaeolithic hominin groups. Their upper first incisors possessed a median wear ratio that was higher than both of the Middle Palaeolithic hominins, with a larger inter-quartile range. In contrast, the Upper Palaeolithic and Early Epipalaeolithic Modern Human upper second incisors and canines showed much lower wear ratios than both Middle Palaeolithic groups, just above that of the first molars. The differences in wear ratios were even greater in the lower dentitions; all the Upper Palaeolithic/Early Epipalaeolithic Modern Humans anterior teeth possessed much lower wear ratios than both groups of Middle Palaeolithic hominins. In fact, their lower second incisors and canines displayed median wear ratios that were less than those of the first molars. The cheek teeth from all three groups of hominin showed similar wear ratios. The Upper Palaeolithic and Early Epipalaeolithic Modern Human upper premolars showed more similar wear ratios to the Neanderthals than to the Middle Palaeolithic Modern Humans.

To highlight any regional differences in wear patterns, the Upper Palaeolithic and Epipalaeolithic Modern Humans were divided into four groups: African, Asian, Central European and Western European. Although the group size varied between regions, the results showed regional differences in tooth wear patterns. The specimens from Central Europe (Dolní Věstonice and Pavlov, Czech Republic) displayed the highest wear ratios for the anterior teeth, relative to the first molars, with large inter-quartile ranges. The specimens from Western Europe also possessed high wear ratios for the lower first incisors. The European specimens therefore appear to be responsible for the high wear ratios exhibited by the anterior teeth in the combined graph for Upper Palaeolithic/Epipalaeolithic Modern Humans.

The Upper Palaeolithic and Early Epipalaeolithic Modern Humans showed different tooth wear patterns to both Neanderthals and Modern Humans associated with Middle Palaeolithic tool kits. In general, these Upper Palaeolithic and Early Epipalaeolithic Modern Humans possessed much lower wear ratios for their second incisors and canines, in relation to their cheek teeth, but maintained higher wear ratios for their first incisors. This reduction suggests a different pattern of tooth use. It may well be that it can be associated with the development of a more specialised and diverse tool kit during the Upper Palaeolithic and Early Epipalaeolithic. New types of tools emerged, such as burins, endscrapers, points, harpoons and needles. Middle Palaeolithic tools were mostly made from stone, but during the Upper Palaeolithic and Early

Epipalaeolithic bone, ivory and antler were frequently used to produce tools such as awls, needles, projectile points, spears and spear throwers (Clay, 1995; Mellars, 2000). It therefore seems reasonable to suggest that this increased diversity in tools and raw materials to produce tools, as well as other cultural changes such as cooking, chemically treating animal skins and the use of containers during food processing, would have had a significant impact on the role of the teeth within these hominin groups.

Summary

Hominins associated with Middle Palaeolithic tool kits (Early Modern Humans and Neanderthals) possessed high levels of wear ratios in their anterior teeth, relative to their cheek teeth. The evenness of this wear varied between these two groups, but this might be explained by differences in the shapes of their dental arcades (above). This heavy anterior wear pattern was different to that shown by the Upper Palaeolithic and Early Epipalaeolithic Modern Humans, where similarly high levels of wear ratios were only present in their first incisors. Differences in facial morphology do not appear to account for this change in wear patterns, as Middle Palaeolithic Modern Humans and Neanderthals possessed very different facial morphologies, but still showed similarly high levels of wear ratios in their anterior teeth. They were both associated with a Middle Palaeolithic tool kit, and based on these results and associations, it seems reasonable to suggest that the difference in wear patterns between groups of Middle Palaeolithic and Upper Palaeolithic/Early Epipalaeolithic hominins was the result of a change in the hominin tool kit; the transition from a standardised Middle Palaeolithic tools to the more specialised and diverse tools of the Upper Palaeolithic. The relationship between tooth wear patterns and tool technologies will be explored further in the following section, which examines tooth wear patterns in the succeeding cultural periods of the Late Epipalaeolithic, Mesolithic and Neolithic.

9.4 – Are Middle Palaeolithic, Upper Palaeolithic and Early Epipalaeolithic Modern Human tooth wear patterns exceptional when compared with the later Modern Humans associated with different tool kits?

The results above suggest that the pattern of tooth wear was indeed different in Middle Palaeolithic Modern Humans and Upper Palaeolithic/Early Epipalaeolithic Modern Humans, with a reduction in wear ratios, relative to the cheek teeth, in two of the

anterior teeth. If this represents a difference in the requirements for the teeth accompanying the change in tool kit during the Upper Palaeolithic and Early Epipalaeolithic, then it might be expected that there would also be a difference between both these groups of fossils and those associated with Late Epipalaeolithic, Mesolithic and Neolithic tool kits.

Late Epipalaeolithic, Mesolithic and Neolithic Modern Humans displayed contrasting patterns of tooth wear in both their upper and lower dentitions. For the upper dentition, Mesolithic Modern Humans showed the highest wear ratios for the anterior teeth, with medians between 1.1 and 1.6. Both upper incisors from the Late Epipalaeolithic group possessed greater median wear ratios than the first molars and equal in the canines. In the Neolithic group, only the first incisors had a higher median wear ratio than the first molar. These three groups also displayed different wear patterns in their upper cheek teeth. Specimens from the Neolithic and Late Epipalaeolithic group showed a pattern of wear ratios that approached that expected from the eruption sequence, although the Late Epipalaeolithic Modern Humans possessed large inter-quartile ranges. In contrast, the Mesolithic Modern Humans showed higher median wear ratios and larger inter-quartile ranges for the upper premolars than both the Neolithic and Late Epipalaeolithic Modern Humans.

Contrasting patterns of wear were also observed in the Late Epipalaeolithic, Mesolithic and Neolithic Modern Human lower dentitions. The Late Epipalaeolithic Modern Humans displayed the highest wear ratios for the anterior teeth, relative to the cheek teeth, with both incisors possessing greater median wear ratios than the first molars. In contrast to the upper anterior teeth, none of the Mesolithic lower teeth showed higher median wear ratios than the first molars. Again, only the Neolithic Modern Humans' first incisors possessed a median wear ratio greater than 1, while the rest of the lower teeth's wear ratios approached that expected from the eruption sequence. The Late Epipalaeolithic Modern Human cheek teeth also displayed a pattern of wear reflected in the eruption sequence, but the Mesolithic dentitions possessed high wear ratios for their premolars and second molars, relative to the first molars.

When these results were compared to the wear patterns of Middle Palaeolithic and Upper Palaeolithic/Early Epipalaeolithic Modern Humans, all three groups showed evidence for a reduction in anterior tooth wear ratios, relative to the cheek teeth. For the upper dentition, this reduction was greatest in the Neolithic Modern Humans, while Mesolithic Modern Humans retained high wear ratios in all their upper anterior teeth

and third premolars. The lower dentitions showed an even greater reduction in anterior wear ratios, relative to the cheek teeth. None of the Mesolithic Modern Humans' lower teeth possessed median wear ratios greater than that of the first molar. Apart from the first incisors the Neolithic Modern Human lower teeth showed a pattern of wear ratios that approaches that expected from the eruption sequence. Late Epipalaeolithic Modern Humans possessed greater median wear ratios than the first molar in their lower incisors.

These results suggest that there was a substantial reduction in the forces being applied to the anterior teeth of Late Epipalaeolithic, Mesolithic and Neolithic Modern Humans, compared to both Middle and Upper Palaeolithic and Early Epipalaeolithic Modern Humans. This is most marked in the Neolithic group. The Neolithic period not only represented a major change in tool technology, but also the development of agriculture and animal husbandry, as well the emergence of the first villages and a more sedentary lifestyle. It seems reasonable to suggest that these factors would have reduced the need to use the teeth as a tool. In contrast, the preceding Late Epipalaeolithic and Mesolithic cultural periods marked a more transitional phase between the highly mobile hunter-gatherer lifestyle of the Late Pleistocene to that of the more sedentary Neolithic agriculturalists. This does indeed appear to be reflected in the tooth wear patterns of the Late Epipalaeolithic and to some extent the Mesolithic Modern Humans.

An interesting feature of the Mesolithic wear pattern was the high wear ratios shown by their lower cheek teeth, relative to the first molar. Overall, these are higher than those observed in any of the other hominin groups included in this study. One possible explanation for this difference is that all of the specimens included within the Mesolithic group came from European coastal sites (see section 7.5). Coastal hunter-gatherers have been well-documented for the extreme nature of their tooth wear, which has been associated with the processing and mastication of abrasive coastal food resources, such as sea shells (Clement, 2000; Davies and Pedersen, 1955; Walker, 1978). It therefore seems reasonable to suggest that an even more highly abrasive diet was responsible for the high wear ratios observed in the Mesolithic specimens lower cheek teeth.

Male and female Neanderthals and male and female modern hunter-gatherers from Igloodik displayed contrasting patterns of wear. The numbers of specimens assigned a male or female sex were too small in the Middle Palaeolithic and Upper

Palaeolithic/Early Epipalaeolithic groups for comparisons to be made. They were, however, large enough in the Late Epipalaeolithic, Mesolithic and Neolithic groups. The biggest contrast between male and female wear ratios was observed in the Late Epipalaeolithic Modern Humans; the males possessed higher wear ratios for the incisors than the females, with larger inter-quartile ranges, while the females possessed higher wear ratios for the upper premolars and lower molars. Only small differences were observed between male and female wear ratios in both the Mesolithic and Neolithic groups. The Mesolithic females showed higher wear ratios in the upper incisors than the males, but lower wear ratios in their lower third molars. In the Neolithic group, the females possessed higher wear ratios for the upper first incisors and canines than the males, but smaller inter-quartile ranges.

Although differences were observed between male and female wear ratios in all three groups, these were much smaller than those observed in the Neanderthals and Inuit. Furthermore, this reduced contrast in male and female wear ratios is also associated with an overall reduction in the wear ratios for the anterior teeth. It can therefore be suggested that a reduction in forces exerted by the anterior teeth during the Late Epipalaeolithic, Mesolithic and Neolithic, could diminish the dental evidence for the sexual division of labour.

Late Epipalaeolithic, Mesolithic and Neolithic Modern Human groups were also divided by region, which revealed contrasting patterns of wear ratios. The Mesolithic group was divided between Scandinavian and French/Portuguese sites. The differences were not large, but the specimens from France and Portugal possessed slightly higher wear ratios in the upper second incisors, canines and third premolars, and lower first incisors, than the Scandinavian specimens. Regional differences were also observed between Asian and European Neolithic Modern Humans; the European specimens possessed higher wear ratios for all the upper teeth than the Asian specimens and slightly higher wear ratios for the lower second incisors. The Neolithic Modern Humans from Asia possessed much higher wear ratios for the first incisors than the Europeans. These differences may reflect regional differences in the use of the teeth within these groups, due to regionally contrasting tool kits or food resources.

The Late Epipalaeolithic group contained a sufficient number of specimens to be divided by site. Four out of these five sites were situated within the same region of Western Asia, the Levant, whilst one site, Wadi Halfa, was from North Africa. Specimens from the sites of el-Wad, Kebara and Wadi Halfa, showed higher wear

ratios in the upper anterior teeth than specimens from Mallaha and Hayonim, and this approached the anterior wear pattern exhibited by the Middle Palaeolithic and Upper Palaeolithic/Early Epipalaeolithic Modern Humans. The specimens from the sites of Mallaha and Hayonim possessed wear patterns that were more similar to those of the Neolithic agriculturalists. These sites also displayed contrasting patterns of wear in their cheek teeth. Specimens from the sites of Kebara and Wadi Halfa possessed higher wear ratios in both upper premolars, than specimens from el-Wad, Hayonim and Mallaha, while specimens from el-Wad showed a higher wear ratio in the upper third molars than specimens from all of the other sites. For the lower dentitions, the pattern of wear changed between sites, with the Modern Humans from Hayonim and Kebara showing the highest wear ratios in the lower anterior teeth, and those from el-Wad, Mallaha and Wadi Halfa possessing median wear ratios for their anterior teeth less than that of the first molars. Modern Humans from the site of Kebara displayed the highest wear ratios in the lower premolars and those from Wadi Halfa possessed high wear ratios in all their lower cheek teeth.

Compared with the Modern Humans from earlier cultural period (Middle and Upper Palaeolithic and Late Epipalaeolithic), Mesolithic and Neolithic Modern Humans showed much smaller regional variations in their wear patterns. All the specimens included in the Mesolithic group came from sites in Western Europe, so large regional differences might not be expected. By contrast the Neolithic group included specimens from sites in Europe and Western Asia, and greater variation might therefore be expected. A reduction in anterior tooth wear ratios during the Neolithic period therefore appears to have been associated with a reduction in regional differences.

In contrast, the Late Epipalaeolithic group showed a large diversity in wear ratio patterns between sites, despite their close geographical location. All four of the sites from the Levant were associated with the same local tool industry, the Natufian, and would therefore have been expected to show a more universal pattern of wear. They do, however, represent a transition within this region from mobile hunter-gatherers to more sedentary agriculturalist. This may well explain the variation in tooth wear patterns between these sites.

Summary

When compared to Middle Palaeolithic, Upper Palaeolithic and Early Epipalaeolithic Modern Humans tooth wear patterns, Late Epipalaeolithic, Mesolithic and Neolithic

Modern Humans show a general reduction in wear ratios in their anterior teeth. This suggests a reduction in the forces being applied to these teeth, caused by a reduction in the reliance on teeth as a tool. Furthermore, specimens from the Neolithic sites show a greater reduction in anterior tooth wear, relative to the cheek teeth, than those from the Mesolithic and Late Epipalaeolithic. It is reasonable to suggest that these reductions were associated with changes in tool technologies, as well as the transition from the mobile hunter-gather lifestyle of the Late Pleistocene towards that of more sedentary Neolithic agriculturalists.

Male and female tooth wear differences also appear to diminish during the Late Epipalaeolithic, Mesolithic and Neolithic and this can be related to a general reduction in anterior tooth wear, relative to the first molars, decreasing the visibility of the sexual division of labour within the dentitions of these populations. There is also a reduction in the visibility of regional differences in the tooth wear patterns of Mesolithic and Neolithic Modern Humans. The inter-site variation in wear patterns shown by the Late Epipalaeolithic Modern Humans appears to represent an extreme case, but highlights the importance of inter-site variation in the study of tooth wear patterns.

Chapter 9 – Conclusions

The new method for measuring the pattern of tooth wear used in this study, combined with availability of a large collection of digital images and published illustrations made it possible to collect a large database of measurements for Neanderthals, Middle Palaeolithic Modern Humans, Upper Palaeolithic and Early Epipalaeolithic Modern Humans. These groups were large enough, at least in some cases, to consider the variability of wear pattern as well as the median differences. Contrary to previous assumptions, the evidence provided by this detailed analysis of Late Pleistocene tooth wear patterns does not directly support the Anterior Dental Loading Hypothesis as an explanation of the selective pressures driving the evolution of the Neanderthals' unique cranio-facial morphology. A simple expectation from this hypothesis is that Neanderthals should have a uniquely heavy concentration of wear in the anterior part of the dentition. While the degree of wear present on their anterior teeth relative to the cheek teeth was high, it was not exceptional when compared to that of Middle Palaeolithic Modern Humans or Upper Palaeolithic and Early Epi-palaeolithic Modern Humans. Both these groups of Modern Humans possessed very different cranio-facial morphologies to the Neanderthals. The Neanderthals did show a unique pattern of wear, with an evenness in the anterior teeth that was not observed in any of the Modern Human groups. This evenness of wear is matched by a wider dental arcade accommodating large anterior teeth, relative to the rest of the dentition. It could be suggested that the Neanderthal facial morphology might be more to do with spreading the application of force across this larger anterior dentition, rather than increasing the overall difference in leverage between anterior or cheek teeth.

The Late Pleistocene hominins all had heavy anterior tooth wear, relative to the cheek teeth, but it was dwarfed by that of the modern Inuit hunter-gatherers from Igloodik. Inuit hunter-gatherers do not therefore represent a direct model for understanding Neanderthal tooth wear patterns and behaviour, but do provide a useful model for understanding the more general relationship between tooth wear and behaviour in past societies. Further research is needed to determine whether the pattern of exceptionally heavy anterior wear, relative to that of the cheek teeth, observed in the Inuit of Igloodik, is common to all Inuit populations and other modern hunter-gatherers. If it can be established that it represents a maximum then this is an important observation.

Neanderthals and Middle Palaeolithic Modern Humans were associated with a similar Middle Palaeolithic industry. The results of this study also showed that they possessed high wear ratios for their anterior teeth, relative to the cheek teeth, suggesting their teeth may have formed an integral part of their tool kits. The heavy anterior wear shown by these Neanderthals and Early Modern Humans is reduced in Upper Palaeolithic, Epipalaeolithic and Mesolithic Modern Humans, and almost absent in Neolithic Modern Humans, which resembles the expected pattern from dental eruption. It seems reasonable to suppose that the development of more diverse tool kits with specialised tools reduced the need for these groups of Modern Humans to use their teeth as tools, but other factors may also have been involved. One possibility is that it is also connected to mobility patterns, with more highly mobile groups only carrying limited tools around the landscape. The dentition would have provided a constantly available tool for such groups. This behaviour is echoed in the Inuit of Alaska, Canada and Greenland who until very recently maintained a highly mobile lifestyle. The combination of a cold climate and access to a limited tool kit appears to have encouraged them to use their teeth in preference to or in addition to tools they carried with them. In contrast, the more sedentary Neolithic populations would have had regular access to a much larger tool kit. Another possibility may relate to the availability of easily fashioned raw materials.

This relationship between teeth and the hunter-gatherer tool kit has been highlighted by this study, but requires further investigation. Inter- and intra-site variability of stone tools is still poorly understood in both the Middle and Upper Palaeolithic (Dibble and Rolland, 1992). A careful review of the literature brought to light few studies of stone tools amongst recent hunter-gatherers (Torrence, 2001). This is mostly because the technology of recent groups has been largely composed of perishable materials, with few stone tools especially after metal became available to them. This makes it difficult to use recent hunter-gatherers for comparison and suggests that, in Palaeolithic sites, a substantial part of the toolkit has probably failed to be preserved. The principal difficulty in understanding stone tool variability is that despite their importance as a class of Palaeolithic remains and the huge numbers found, stone tools probably represent only one element of material culture and we have no way of knowing how large an element. Fossil hominin teeth are a substantial class of finds. A striking feature of recent hunter-gatherers was the large part played by their teeth, not only for eating, but for food preparation and many operations in the manufacture and maintenance of artefacts (Barrett, 1977). Comparisons need to be drawn between the tool technologies and tooth wear patterns within communities of recent hunter-

gatherers living in different environments with different tool kits and diets. Understanding this variability in modern hunter-gatherers will enable us to better understand the variability in Late Pleistocene Modern Humans.

The new quantitative and 2-D method for measuring and assessing tooth wear can be widely applied to other groups of hominins, both ancient and more recent. Further development is, however, needed to allow the inclusion of specimens at the extremes of the wear spectrum. Currently it is not possible to measure teeth before the dentine has been exposed on its occlusal surface, even if substantial amounts of enamel have already been worn away. Similarly, once the dentine proportion of the occlusal wear facet has reached 1 no further measurements of wear can be taken. This means that tooth wear cannot be recorded in specimens showing extremely heavy patterns of wear, such as the Gibraltar I Neanderthal. The method was only applied to adult specimens, but it could readily be developed further to include adolescents and juveniles with mixed and deciduous dentitions. This would be of particular interest in the Neanderthals for which a substantial amount of material is available (Skinner, 1997).

This study was necessarily limited to recording occlusal wear, but the method could be easily adapted to measure other types of wear such as approximal wear. Approximal attrition has previously been difficult to record, as neighbouring teeth are pressed closely together. As occlusal wear reduces the height of the tooth crown it exposes the edges of the approximal facets, which can be measured to give an estimate of size of the approximal facet. Originally, calipers were used directly, but measurements can be taken using the same photographs and image analysis software as used to measure the dentine proportions in this thesis. It would also be possible to look at the distribution of dentine exposure on the occlusal surface and to ascertain whether this changes between the different groups. Earlier work by Molnar and Molnar (1990), for example, has shown that the shape of the dental arch affects the distribution of wear facets.

This new method for recording tooth wear patterns is consistent when measuring wear from digital images of original fossils and casts, and published illustrations, as well as between different observers. It therefore provides a powerful tool for comparing tooth wear patterns between large groups of specimens. Its application to a known age group of hunter-gatherers from Igloolik highlighted the appearance of wear patterns at an early age which remained constant throughout the different age groups. The

analysis of wear patterns in other groups of modern hunter-gatherers, who inhabit a variety of environments and for whom a significant ethnographic literature exists, has the potential to greatly increase our understanding of Late Pleistocene hunter-gatherer tooth wear patterns and their tool kits.

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